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Monthly Report

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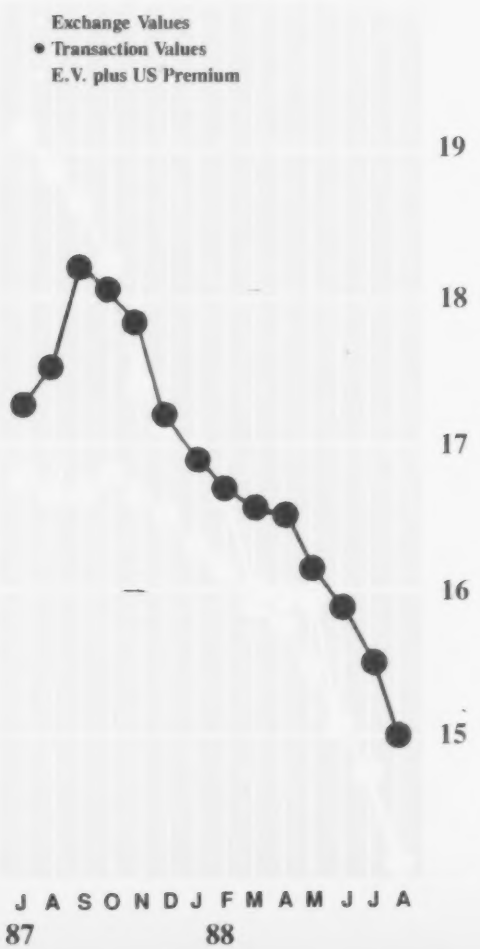

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

September 1988 **No. 241**

R. GENE CLARK, ***EDITOR*** **FRANCE A. HEAD,** ***ASSOCIATE EDITOR***

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To Our Readers

* * *

Five months ago, we noted the founding of NUEXCO in May 1968, and this month we celebrate the twentieth anniversary of the NUEXCO Monthly Report.

Changing market conditions significantly influenced the content and growth of the Monthly Report over the past twenty years, and led to the establishment of the various NUEXCO market values. On page 25 of this issue we have reprinted the first NUEXCO Monthly Report cover and the market values table which were published in September 1968. At that time, the NUEXCO Monthly Report consisted of three pages, and listed yellowcake and UF_6 deposits and loan requests, in addition to the market values.

In search of a historical perspective on the nuclear power industry and the forces that gave rise to NUEXCO's formation and development, we interviewed George White, one of NUEXCO's co-founders, and Bob Wolcott, an early director of the company, who reminisced about those early years.

We also thought it would be interesting to step back even further in time and explore how uranium was first discovered and what its applications were prior to the nuclear power age.

We direct our many thanks to you, our supportive readers, for the success of the Monthly Report, as we continue striving to meet your business needs for selective and timely information, analyses, recent developments, and feature articles.

* * *

NUEXCO will be hosting a hospitality suite at the U.S. CEA Uranium Seminar to be held September 25-28 in Tucson, Arizona. We look forward to seeing you there.

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MARKET VALUES SUMMARY

August 31, 1988	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE[1]	**$14.15**/lb U_3O_8	7,300[2]	1,574[2]
US Premium[7]	**- 0 -**		
UF_6 VALUE[2]	**$41.00**/kg U as UF_6	7,300[2]	1,574[2]
US Premium	**- 0 -**		
CONVERSION VALUE[3]	**$1.95**/lb U as UF_6	0	900
SWU VALUE[4]			
0.3 tails assay:	**$65**/SWU	770	95
LOAN RATE[5]	**3.5%**/annum	5,950	0

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE[6]	**15.00**	**2.9**	**15**	**3**

[1]Supply and demand tables in the *Current Market Data* section of this Report detail the numbers for each category.
[2]For either uranium concentrates or uranium hexafluoride.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

   The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.
7. The **US Premium** is Nuexco's judgment of the incremental price (relative to the Exchange Value or UF_6 Value, as applicable) at which transactions for significant quantities of natural uranium could be concluded as of the date indicated, if the buyer will accept only US-origin.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of prices, Nuexco does not consider transportation charges other than those customarily provided by suppliers .
4. The prices of services or materials delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U_{235} and a product assay of 3.0 weight-percent U_{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

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NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of August 31, 1988)

Market volume increased this month with approximately 6.8 million pounds U_3O_8 equivalent traded in five near-term and two long-term transactions. In the secondary conversion market, the two transactions reported last month as pending were concluded during August. One secondary SWU transaction took place involving DOE-origin SWU.

The **Exchange Value** fell to **$14.15** per pound U_3O_8, a $0.60, or more than four percent, decrease from last month, as recent transactions and aggressive sellers continue to exert downward pressure on uranium prices. The Exchange Value is now at its lowest level since October 1974, and in real dollars (adjusted for inflation), it represents the lowest price level ever during the 20 years the NUEXCO Exchange Value has been published (see Figure 1). The steady price decline over the past year reflects the continued availability of low-priced supply from a variety of sources, several of which are offering significant quantities of U_3O_8 at prices near the Exchange Value.

Contrary to classic economic principles, the appearance of new buyers in the current market has led to downward pressure on prices as numerous sellers competed aggressively for every sales opportunity that became available. As long as these sellers remain in the market, this dynamic is likely to continue, and even moderate increases in demand may fail to generate higher prices. Suppliers include US and non-US producers interested in moving large quantities of new production as well as inventories, European entities with large inventories, and material liberated through complex transactions. Excess inventories now approximate 200 million pounds U_3O_8 equivalent, or nearly two years of forward requirements.

Essentially all market participants — utilities, producers, traders, and consultants — tend to agree that current spot price levels are too low to motivate and sustain, in the long-term, production of sufficient uranium to meet future reactor requirements. That the market should behave in a manner so contrary to the apparent long-term interests of both utilities and producers has been a matter of continuing concern and frustration.

Factors inhibiting any near-term price recovery include:

- the reduction and deferral of real uranium demand as a consequence of excess inventories,
- the continued availability of low cost and/or low-priced uranium from new suppliers of natural and enriched material now competing for market share, and
- continued competition from less conventional transactions involving de-enrichment and deconversion swaps and liquidations of the excess inventories.

In addition, most current procurement activity in the spot market is discretionary and thus extremely price sensitive. Almost all buyers have been able to obtain comparable and increasingly favorable contract terms. In hindsight, it may well be that the timing of the current price decline has been merely deferred and its severity perhaps increased, as a consequence of legal and political events which interferred, albeit only temporarily, with the free interaction of the normal market forces of supply and demand.

Six U_3O_8 transactions are reported this month involving approximately 6.5 million pounds, four of which were for near-term delivery. Two transactions which were concluded early in the month were at prices slightly higher than those finalized near the end of the month, and involved a relatively scarce origin attractive to some utilities because of its unrestricted nature. Three buyers are now in the market for U_3O_8 for delivery prior to year-end. The impending market response to their requests, totaling about 700,000 pounds U_3O_8, will provide an indication of whether prices will stabilize at the current level or decline further.

* * *

The **US Premium** for **U_3O_8** remains at zero, as most buyers refuse to pay a premium for US-origin material. In addition, most suppliers are willing to sell US-origin material at current prices, and it appears that very few sellers believe a premium is attainable in the current market. Legislative uncertainties and stagnation in the US Producer vs. DOE lawsuit has focused attention on the US-Canada Free Trade Agreement (FTA), which has been approved in the USA by the House and is expected to pass in the Senate this fall, but has encountered difficulties in Canada. Anti-FTA forces in Canada may have succeeded in making the FTA an election issue, which could jeopardize or delay its passage.

* * *

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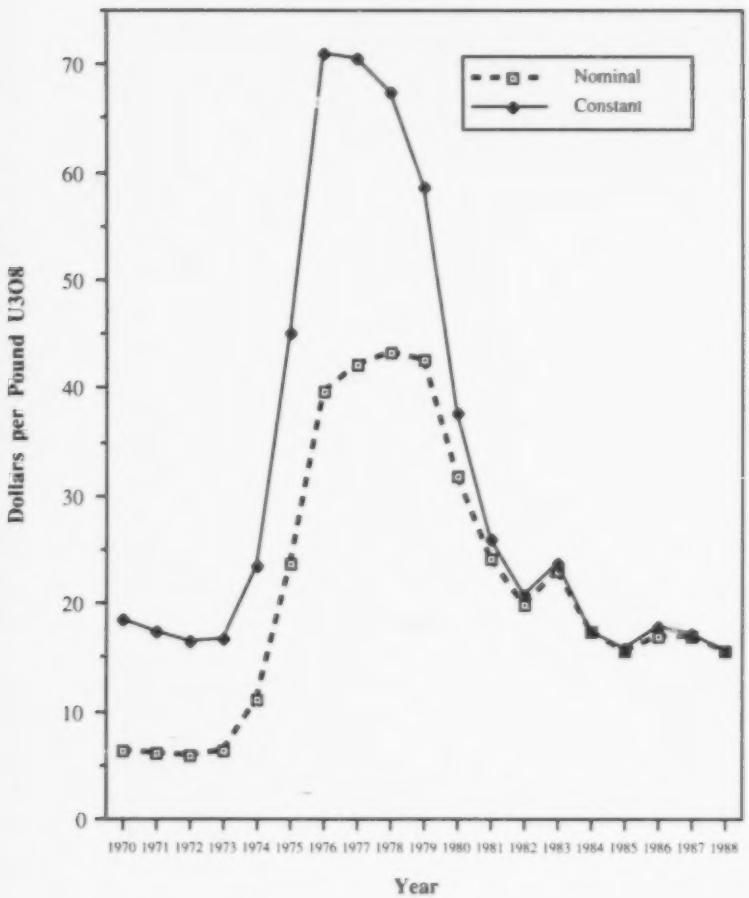
Figure 1
HISTORICAL NUEXCO EXCHANGE VALUES
(Annual Average)



Active supply of natural uranium (concentrates and UF6) for spot delivery totals **7.3 million pounds** U3O8 equivalent, a decrease of approximately 600,000 pounds since last month. **Active demand** for natural uranium also dropped slightly to **1.6 million pounds**, from the 1.7 million pounds previously reported. The net result of these fluctuations is an unchanged **supply/demand ratio** of **4.6 to 1** for the near-term.

The **Transaction Value** declined to **$15.00** per pound U3O8, a $0.45 reduction from the prior month, as higher-priced transactions from May were removed from the calculation. The calculation extends over a three-month period and includes 15 transactions involving approximately 2.9 million pounds U3O8 equivalent.

* * *

The **UF6 Value** declined to **$41.00** per kilogram U as UF6, a $1.75 change from the previous month, in response to the same pressures that affected the Exchange Value. One entity's attempts to sell a large quantity of UF6 inventory has been met with little interest, and potential buyers are seeing increasingly aggressive offers. One UF6 transaction was concluded this month at a price near the current value, but little firm demand for UF6 is anticipated through year-end. The **US Premium** for **UF6** also remains at zero, and has been affected by the same factors as the US Premium for U3O8.

* * *

The **Loan Rate** is unchanged at **3.5 percent** per annum, and one U3O8 loan transaction is reported. There continues to be little demand for loans in a market in which purchases are so economically attractive.

* * *

The **Conversion Value** rose to **$1.95** per pound U as UF6, an increase of $0.10, in response to a strengthening secondary conversion market. Several utilities have expressed interest in significant quantities of conversion services over the next nine months, straining available UF6 supplies, particularly when origin restrictions are applied. Although UF6 supplies for sale remain abundant, conversion transactions require the disposal of U3O8 liberated from the transaction, which sharply limits the

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availability of these types of transactions. Two secondary conversion transactions are reported this month; one involved a European buyer and took place at a price slightly above the current value, and is representative of the somewhat stronger European market for conversion.

ENRICHMENT SERVICES AND SWU

The **SWU Value** dropped to **$65 per SWU**, a $3-per-SWU reduction, in light of low-priced offers in the market. One sale of DOE-origin SWU was completed on a spot basis, another transaction for longer-term supply is in negotiation, and several others could be concluded soon to fulfill requirements in the 1991-95 timeframe. The emergence of low-priced supply has drawn discretionary buyers into the marketplace, resulting in a more active SWU market than in early 1988.

* * *

US LEGAL AND POLITICAL DEVELOPMENTS AUGUST 1988

Aug. 2 – The House voted to renew the **Price-Anderson Act** for an additional 15 years, raising the total potential funds available in the case of a nuclear accident to $7 billion. The Senate gave its approval on August 5, and the Act was subsequently signed into law by President Reagan.

Aug. 8 — The Senate passed the **Nuclear Regulation Reorganization & Reform Act (S. 2443)** which provides for the reorganization of the Nuclear Regulatory Commission (NRC), encourages a rulemaking on standardization of nuclear power plant designs, and includes the uranium compromise package establishing a $750 million government purchase program for domestic uranium, a uranium mill tailings fund, and a government-owned uranium enrichment corporation. The House is not expected to support this bill because of strident opposition to the uranium compromise package. The uranium package may yet be tacked onto another bill if S. 2433 is unsuccessful.

Aug. 9 — The House passed the implementing legislation for the US/Canada Free Trade Agreement (FTA) by a 366 to 40 vote, and the Senate Energy & Natural Resources Committee also approved the legislation. Although it still must be reviewed by several other Senate committees, it is expected to reach the Senate floor for full consideration sometime in September and pass. In Canada, the House of Commons approved the Agreement, and it has now moved on to the Senate where its future is uncertain.

Aug. 11 — The House approved a revised version of the **South African sanctions bill** which would prohibit the import of South African UF_6. On September 8, the Senate Foreign Relations Committee is scheduled to mark up the sanctions bill which, if revised, is likely to be less comprehensive than the House version. It is uncertain whether the bill will reach the Senate floor before Congress adjourns in October.

Aug. 17 — US District Court Judge James Carrigan has ordered a conference on October 12 to schedule further proceedings in the **US Producers vs. DOE lawsuit**.

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EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 as Concentrates			per kg U as Concentrates		
	This Month (August 31, 1988)	Last Month (July 31, 1988)	12 Months Ago (August 31, 1987)	This Month (August 31, 1988)	Last Month (July 31, 1988)	12 Months Ago (August 31, 1987)
Australia (dollar)	17.57	18.35	23.41	45.67	47.70	60.86
Belgium (comm. franc)	554.03	574.60	627.59	1,440	1,494	1,632
Canada (dollar)	17.50	17.82	21.94	45.49	46.34	57.05
EEC (ecu)	12.75	13.11	14.61	33.16	34.09	37.99
Finland (markka)	62.64	64.98	73.25	162.85	168.93	190.44
France (franc)	89.61	92.65	100.73	232.98	240.87	261.86
FRG (mark)	26.41	27.49	30.16	68.66	71.48	78.42
Italy (lira)	19,598	20,311	21,845	50,951	52,805	56,791
Japan (yen)	1,910	1,953	2,363	4,964	5,076	6,144
Netherlands (guilder)	29.81	31.05	33.99	77.51	80.71	88.38
South Africa (rand)	34.37	35.96	33.91	89.35	93.48	88.16
Spain (peseta)	1,748	1,812	2,031	4,544	4,710	5,281
Sweden (krona)	91.17	94.13	106.19	237.03	244.71	276.06
Switzerland (franc)	22.30	22.86	24.85	57.98	59.43	64.61
UK (pound)	8.38	8.56	10.19	21.78	22.26	26.50
US (dollar)	14.15	14.75	16.65	36.79	38.35	43.29

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 as Concentrates			per kg U as Concentrates		
	This Month (August 31, 1988)	Last Month (July 31, 1988)	12 Months Ago (August 31, 1987)	This Month (August 31, 1988)	Last Month (July 31, 1988)	12 Months Ago (August 31, 1987)
Australia (dollar)	18.62	19.22	24.68	48.41	49.96	64.15
Belgium (comm. franc)	587.31	601.87	661.52	1,527	1,565	1,720
Canada (dollar)	18.55	18.67	23.13	48.22	48.54	60.13
EEC (ecu)	13.52	13.73	15.40	35.15	35.71	40.04
Finland (markka)	66.40	68.06	77.21	172.63	176.94	200.73
France (franc)	95.00	97.05	106.17	246.97	252.30	276.02
FRG (mark)	28.00	28.80	31.79	72.78	74.87	82.66
Italy (lira)	20,776	21,275	23,025	54,012	55,311	59,861
Japan (yen)	2,024	2,045	2,491	5,263	5,317	6,476
Netherlands (guilder)	31.61	32.52	35.83	82.17	84.54	93.15
South Africa (rand)	36.43	37.66	35.74	94.72	97.92	92.92
Spain (peseta)	1,853	1,898	2,141	4,817	4,933	5,566
Sweden (krona)	96.65	98.60	111.93	251.27	256.33	290.98
Switzerland (franc)	23.64	23.95	26.19	61.46	62.25	68.10
UK (pound)	8.88	8.97	10.74	23.09	23.31	27.93
US (dollar)	15.00	15.45	17.55	39.00	40.17	45.63

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on the last working day of the month.

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CURRENT MARKET DATA

CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb U as UF_6			per kg U as UF_6		
	This Month (August 31, 1988)	Last Month (July 31, 1988)	12 Months Ago (August 31, 1987)	This Month (August 31, 1988)	Last Month (July 31, 1988)	12 Months Ago (August 31, 1987)
Australia (dollar)	2.42	2.30	2.67	5.34	5.07	5.89
Belgium (comm. franc)	76.35	72.07	71.62	168.32	158.88	157.89
Canada (dollar)	2.41	2.24	2.50	5.32	4.93	5.52
EEC (ecu)	1.76	1.64	1.67	3.87	3.63	3.68
Finland (markka)	8.63	8.15	8.36	19.03	17.97	18.43
France (franc)	12.35	11.62	11.49	27.23	25.62	25.34
FRG (mark)	3.64	3.45	3.44	8.02	7.60	7.59
Italy (lira)	2,701	2,548	2,493	5,954	5,616	5,496
Japan (yen)	263.16	244.90	269.69	580.16	539.92	594057
Netherlands (guilder)	4.11	3.89	3.88	9.06	8.58	8.55
South Africa (rand)	4.74	4.51	3.87	10.44	9.94	8.53
Spain (peseta)	240.86	227.22	231.79	531.00	500.93	511.01
Sweden (krona)	12.56	11.81	12.12	27.70	26.03	26.71
Switzerland (franc)	3.07	2.87	2.84	6.78	6.32	6.25
UK (pound)	1.15	1.07	1.16	2.55	2.37	2.56
US (dollar)	1.95	1.85	1.90	4.30	4.08	4.19

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	SWU Value at 0.30% Tails Assay This Month (August 31, 1988)	SWU Value at 0.30% Tails Assay Last Month (July 31, 1988)	UF_6 Value per kg U as UF_6 This Month (August 31, 1988)	UF_6 Value per kg U asUF_6 Last Month (July 31, 1988)
Australia (dollar)	80.70	84.59	50.90	53.17
Belgium (comm. franc)	2,545	2,649	1,605	1,665
Canada (dollar)	80.38	82.18	50.69	51.66
EEC (ecu)	58.58	60.45	36.95	38.00
Finland (markka)	287.74	299.56	181.49	188.32
France (franc)	411.65	427.14	259.65	268.53
FRG (mark)	121.31	126.75	76.52	79.68
Italy (lira)	90,028	93,638	56,787	58,868
Japan (yen)	8,772	9,002	5,533	5,659
Netherlands (guilder)	136.96	143.13	86.38	89.98
South Africa (rand)	157.88	165.77	99.58	104.21
Spain (peseta)	8,029	8,352	5,064	5,251
Sweden (krona)	418.81	433.95	264.17	272.81
Switzerland (franc)	102.44	105.39	64.61	66.25
UK (pound)	38.48	39.47	24.27	24.81
US (dollar)	65.00	68.00	41.00	42.75

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on the last working day of the month.

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RECENT TRANSACTIONS[1]

URANIUM SALES

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price Range as Percent of Current Exchange or UF_6 Value[2]	Seller	Buyer	Remarks
4349	1991-95	1,501-3,000	See Remarks	Producer	Utility	Market-Related Pricing
4350	1991-95	1,501-3,000	See Remarks	Producer	Utility	Market-Related Pricing
4357	1988-91	601-1,000	R[3]	Producer	Utility	
4359	1988	101-300	103-107	Intermediary	Utility	
4360	1988	101-300	98-102	Producer	Intermediary	UF_6
4361	1989	50-100	98-102	Intermediary	Utility	
4368	1988	601-1,000	103-107	Intermediary	Utility	

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2] Where US-origin material is involved, the range is based on the Exchange Value (or UF_6 Value) *plus* the premium (relative to the Exchange Value or UF_6 Value). The range reflects five percentage points (inclusive) per grouping, centered about the middle of the range.
[3] The notation R means that Nuexco either does not know, or that Nuexco has restricted that information to protect client or source confidentiality.

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CURRENT MARKET DATA

LOAN TRANSACTIONS

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price Range as Percent of Current Loan Rate	Lender	Borrower	Remarks
4358	1988-89	100-300	R[3]	Intermediary	Intermediary	

CONVERSION SERVICES
SECONDARY MARKET SALES

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price Range as Percent of Current C.V.	Seller	Buyer	Remarks
4353	1988	101-300	83-87	Intermediary	Utility	
4366	1988	101-300	123-127	Intermediary	Utility	

ENRICHMENT SERVICES
SECONDARY MARKET SALES

Nuexco Transaction Number	Delivery Period	Approximate Quantity[4] (thousands of SWU)	Approximate Price Range as Percent of Current SWU Value[5]	Seller	Buyer	SWU Origin	Remarks
4362	1988	less than 50	113-117	Intermediary	Utility	DOE	

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2] Where US origin material is involved, the range is based on the Exchange Value (or UF_6 Value) *plus* the premium (relative to the Exchange Value or UF_6 Value). The range reflects five percentage points (inclusive) per grouping, centered about the middle of the range.
[3] The notation R means that Nuexco either does not know, or that Nuexco has restricted that information to protect client or source confidentiality.
[4] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[5] Prices are usually normalized to 0.30% tails assay. Refers to SWU Value that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts from a reference price (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage price range is based on the discounted prices, not on the reference price.

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URANIUM SUPPLY
(August 31, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale			
ACTIVE			
87-1002	270	—	1988
87-1068A*	1,000	—	UF_6e
87-1123	1,000	1,000 per year	1988
87-1141	500	200 per year	1989-92
88-1000A*	50	—	1988
88-1000B*	200	—	1988, UF_6
88-1001*	200	—	1988
88-1026	250	—	1988
88-1036	100	—	1988
88-1041	680	—	1988, UF_6
88-1078	1,200	—	1988
88-1153*	100	—	1989
88-1155*	750	—	1989, UF_6
88-1157*	1,000	1,000 per year	1989 on
87-1101	—	500 per year	1989 on
87-1005	—	250 per year	1989-95
87-1061*	—	700 per year	1989 on
88-1096A	—	290	1990, UF_6e
Total	**7,300**		
INACTIVE			
87-1019	1,000	1,000 per year	1988-91
87-1053	100	500 per year	1989 on
88-1033A	130	—	1988, UF_6e
88-1064*	400	400 per year	1988-90
88-1122*	365	—	1988, UF_6
87-1000*	—	1,000 per year	1990-93
87-1130	—	580	1989
Total:	**1,995**		

* New or revised since last month.
[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 87-1023, 87-1159, 87-1161, 88-1086, 88-1120.

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CURRENT MARKET DATA

URANIUM DEMAND
(August 31, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
87-1154A*	44	—	UF_6e
88-1103	250	—	1988
88-1115*	325	—	1988
88-1126*	250	—	1988
88-1133*	200	—	1988
88-1144*	15	—	U_3O_8/UF_6
88-1147*	130	—	1989, UF_6
88-1148*	45	—	1988, UF_6
88-1149A*	45	—	1989, UF_6e
88-1151*	100	—	1988, UF_6
88-1154*	150	—	1988, UF_6
88-1156*	20	—	1988
87-1134	—	260	1989
88-1089	—	1,200 per year	1990-95
88-1107A	—	100	1989, UF_6e
Total:	**1,574**		
INACTIVE			
88-1084	500	—	1988
Total	**500**		

* New or revised since last month.
[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 87-1163, 87-1172, 88-1035A, 88-1062, 88-1083, 88-1094, 88-1106.

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LOAN SUPPLY AND DEMAND
(August 31, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
ACTIVE			
87-1012	1,000	—	
87-1157	4,000	—	
88-1057	600	—	
88-1135*	200	—	
88-1139*	150	—	
Total:	**5,950**		
INACTIVE			
87-1031	1,000	—	
87-1033	1,000	—	
Total:	**2,000**		

Available to Borrow:

No inquiries to borrow are reported.

* New or revised since last month.
[1] Measured from the date of this Report.
Projects removed since last month: None

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CURRENT MARKET DATA

CONVERSION SUPPLY AND DEMAND
(August 31, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale			
ACTIVE			
No active conversion supply is reported this month.			
INACTIVE			
87-1008	770	475	1988
Total:	**770**		
Inquiries to Purchase			
ACTIVE			
88-1034*	110	5,000	1989-2000
88-1113*	250	—	1989
88-1127*	40	—	1988
88-1158*	500	5,000	1989-93
Total:	**900**		
INACTIVE			
88-1021	65	—	
Total:	**65**		

* New or revised since last month.
[1] Measured from the date of this Report.
Projects removed since last month: 88-1059 and 88-1098.

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SWU SUPPLY AND DEMAND
(August 31, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of SWU) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale			
ACTIVE			
87-1058	20	—	
87-1068B*	250	—	UF6e
88-1065	500[3]	500	1990, UF6e
88-1096B		55	1990, UF6e
Total	**770**		
INACTIVE			
87-1128	360	—	1988
88-1033B	15	—	UF6e
88-1082	25	—	1988
Total:	**400**		
Inquiries to Purchase			
ACTIVE			
87-1154B*	10	—	UF6e
88-1085	10	—	1988
88-1149B*	15	—	1989, UF6e
88-1107B*	60	—	1989, UF6e
88-1077[4]	—	70	1989-91
Total:	**95**		
INACTIVE			
None reported			

* New or revised since last month.
[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes SWU deliverable within one year under other than spot or near-term contracts.
[3] SWU supply now estimated to fall within the near-term time frame.
[4] Transaction pending.
Projects removed since last month: 87-1004, 88-1035B.

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RECENT DEVELOPMENTS

NAMIBIA

Tentative Accord Reached on Namibian Independence

The territory of Namibia (formerly South West Africa) (Figure 1), which has been ruled by the Republic of South Africa for more than seventy years, could become politically independent by June 1989, according to a peace plan agreed to in principle by the governments of South Africa, Angola, and Cuba. If the treaty now under negotiation takes effect and a new Namibian government is formed democratically, Namibia's important uranium mining company, Rössing Uranium Limited (RUL) (Table 1), is likely to become a highly competitive U_3O_8 supplier in the international market. Until now, RUL's marketing efforts — particularly in North America and northern Europe — have been substantially hindered by Namibia's political association with South Africa. RUL produced over nine million pounds of U_3O_8 in 1987, making Rössing the world's second largest producing uranium mine and Namibia the fifth largest uranium producing country in the world (Table 2). (See NUEXCO Report Numbers 188 and 189 on the Rössing Project.)

The tentative accord on Namibian independence agreed to in early August by South Africa, Angola, and Cuba contains the following key provisions:

- South Africa, which has been supporting the Angolan rebel group UNITA (National Union for the Total Independence of Angola) and attacking the Namibian insurgent group SWAPO (South West Africa People's Organization) in southern Angola, was to withdraw from Angola by September 1. By that date, Angola and Cuba were to present an acceptable schedule for the withdrawal of Cuban forces from Angola. With an estimated 54,000 troops, Cuba has been supporting the communist Angolan government in its efforts to defeat UNITA and assist SWAPO.
- South Africa will withdraw the estimated 50,000 troops it now has positioned in Namibia by February 1, 1989. The South African military presence in Namibia will be replaced by a United Nations (UN) peacekeeping contingent of 7,500 soldiers.

Table 1
BENEFICIAL OWNERSHIP OF ROSSING URANIUM LTD.

Company	Country	Percent Share
The RTZ Corporation[1]	UK	41.4
Industrial Development Corp.	South Africa	10.0
Total Compagnie Miniere	France	10.0
Rio Algom Ltd.[1]	Canada	10.0
Urangesellschaft mbH	FRG	5.0
Capricorn Trust[2]	Namibia	3.4
General Mining Corp.	South Africa	2.3
Undisclosed		17.9
		100.0

[1] RTZ owns 51.3 percent of Rio Algom, so RTZ's net beneficial interest in Rössing is 46.5 percent.

[2] The Capricorn Trust is a private trust established to keep and manage shares in Rossing for the people of Namibia. The trustees are two professional persons from the Namibian capital, Windhoek. The shares were transferred to the Trust by the South African-controlled government in 1987 in accordance with the government's policy not to be involved in private mining ventures. Dividend income is used for educational and other purposes for the benefit of the Namibian people. The Capricorn Trust is represented on RUL's Board of Directors.

Table 2
WORLD URANIUM PRODUCTION IN 1986 AND 1987
(Millions of Pounds U_3O_8)

Country	1986	1987	Percent Change
Australia	10.8	9.8	- 9.3
Canada	30.5	32.3	+ 5.9
France	8.5	8.6	+ 1.2
Gabon	2.2	2.1	- 4.5
Namibia	9.1	9.2	+ 1.1
Niger	8.2	7.8	- 4.9
South Africa	12.0	10.3	-14.2
United States	13.9	12.5	-10.1
Other[1]	2.1	2.3	+ 9.5
TOTAL	**97.3**	**94.9**	**- 2.5**

[1] Includes Argentina, Belgium, Brazil, India, Pakistan, Portugal, Spain, and Yugoslavia.

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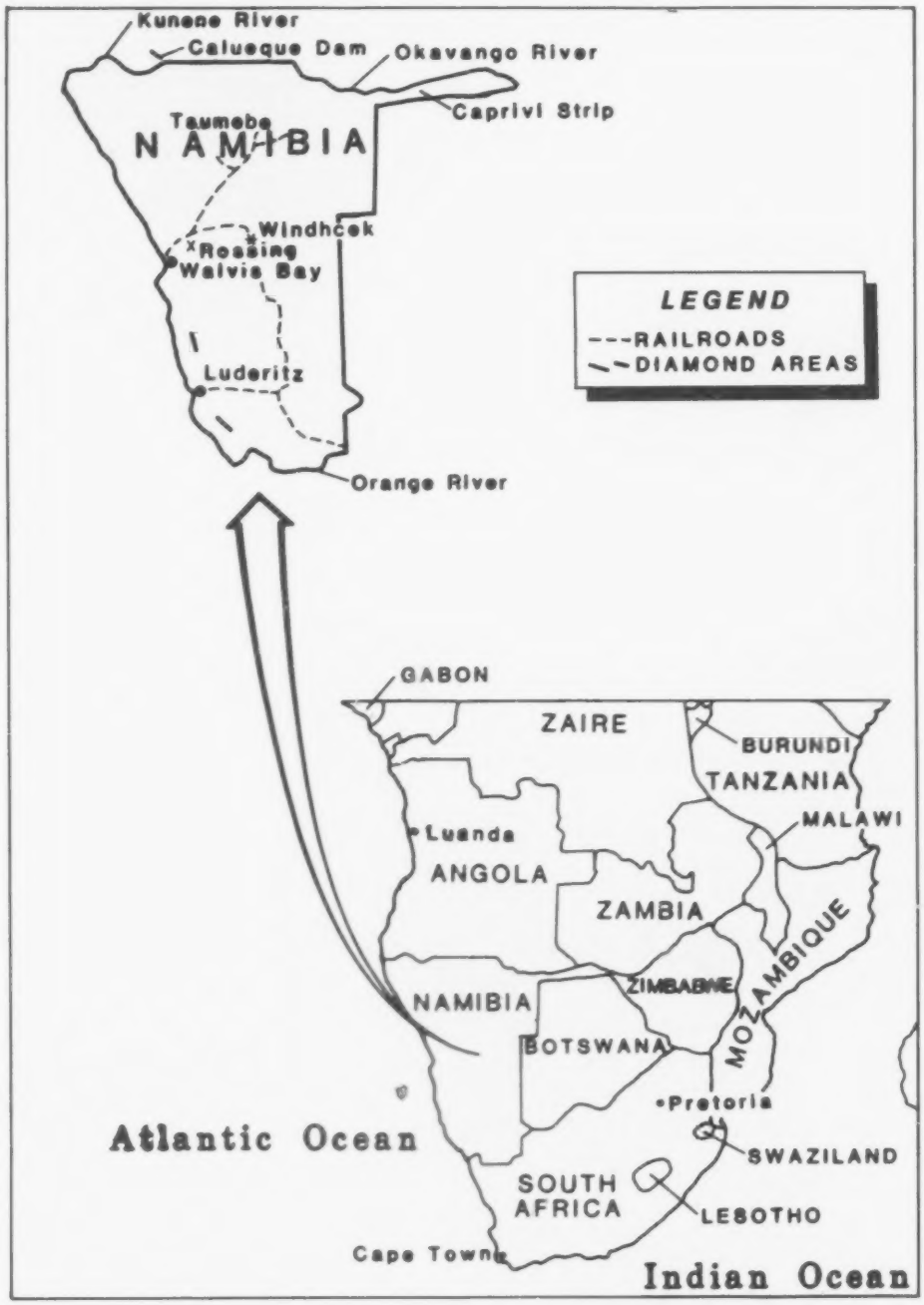

Figure 1. Map of southern Africa showing location of Rossing mine, Namibia.

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Figure 2. The Rossing open-pit mine. *(Photo courtesy of The RTZ Corporation.)*

• The United Nations will take responsibility for implementing Resolution 435 (1978) of the UN Security Council, which calls for political independence and democratic elections in Namibia.

All sides in the current negotiations appear to be highly interested in the conclusion of a treaty. The current momentum in the peace negotiations began early this summer after a massive buildup of Cuban and South African military forces in southern Angola (Figure 1). Opposing combat units have been situated within ten kilometers of each other at some points near the border. In June, following a Cuban air attack on the South African-held Calueque Dam in which eleven South African soldiers were killed, the South African government ordered all its troops to withdraw south of the border, a tactical retreat signaling South Africa's desire to avoid heavy fighting. Clearly the imminence of a relatively serious conventional war prompted all sides to reevaluate their strategic interests, and it should continue to provide the impetus toward signature of a treaty. However, while the general principles of a settlement have been agreed to, a number of difficult issues surrounding the guerilla movements in the region remain unresolved and may delay the achievement of Namibian autonomy.

In a statement issued June 2, 1988 to the RTZ Corporation's Annual General Meeting in London, the Chairman of RTZ, Sir Alistair Frame, commented on Namibian independence and the importance of Rössing. (RTZ is the largest shareholder in RUL.)

"(RTZ) believes Namibia's best interests, and those of all Namibians, would be served if all concerned could speedily achieve an internationally recognized and accepted independence through which Namibians as a whole can decide for themselves the future of their country. . . Rössing is steadfastly opposed to racial discrimination in the workplace and the community as a whole. . . Rössing's practical example is a model to be followed by those organizations and people who wish to be part of the emergent Namibia. . .The company contributes more than R400 million (approximmately US $235 million) a year to the Namibian economy by way of salaries, purchases of goods and services locally, and corporate taxes. It accounts for almost 20 percent of Namibia's Gross Domestic Product and approaches 40 percent of Namiba's exports." (Greater than 90 percent of Namibia's 1.2 million people are black; per capita Gross Domestic Product (GDP), at US $1,250, is one of the highest in Africa.)

RTZ, which originally owned 100 percent of RUL, took the decision to develop Rössing in August 1973 following several years of geologic studies, at a time of heavy investment internationally in nuclear energy. Mining and mill construction began in 1974; the first concentrates were produced in mid-1976. By 1979, Rössing's output had reached nearly ten million pounds U_3O_8 per year. The open-pit mine (Figure 2), located in the Namib Desert about 70 kilometers from the Atlantic coast, is the largest uranium mine in the world, measured by earth movement, with an output of over 40,000 metric tons of ore and 100,000 metric tons of waste per day. Rössing's reserves are sufficient for continued production well into the next century. ■

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A HISTORICAL PERSPECTIVE ON NUEXCO

Conversations with George White and Bob Wolcott

George White

In commemoration of NUEXCO's twentieth anniversary, we talked with one of NUEXCO's founders, Mr. George White, and an early director of the company, Mr. J. Robert (Bob) Wolcott, about the early days of the uranium industry and NUEXCO's formation and subsequent evolution.

After receiving a degree in chemical engineering from Princeton University, Mr. White was employed by Shell Oil and other companies, and served as Executive Vice President of Vitro Corporation of America from 1948 until 1956 when he joined General Electric (GE) as General Manager of the Atomic Power Equipment Department. There his assigned mission was to manage GE's entrance into the commercial nuclear power business. In 1968, Mr. White founded NUEXCO together with Mr. A. Payne Kibbe (now deceased), and served as its President through 1976. Mr. White was chairman of NUEXCO's Executive Committee until March 1982, and Chairman of the Board until his retirement in October 1982. He currently resides in Pebble Beach, California.

Bob Wolcott, former President (1977-82) and Chairman (1983-85) of NUEXCO, is also a GE alumnus, having spent twenty years with that company. He was the Design Manager for the Dresden 1 nuclear power station — GE's first commercial venture in nuclear power. He also held senior management positions in manufacturing and international areas of GE's nuclear business. In 1968, Mr. Wolcott left GE to establish his own consulting business before joining NUEXCO in 1977. Currently, he is Chairman of the Concord/NUEXCO International Advisory Committee.

Bob Wolcott

NUEXCO: I'd like to go back to the beginning, when NUEXCO was just an idea. How did it all start?

GW: Well, there are two different threads that come together here. First, I was working for GE as the head of their commercial nuclear power business. By 1967, things had gotten pretty tough and, for a number of reasons, we were losing money on our jobs. There was rampant inflation and the start of the anti-nuclear movement, which made our plants more difficult and more expensive to build. The net result was that the general management of GE was not as aggressive toward nuclear development as they had been earlier.

So then I started thinking about doing some other things, one of which was to go into the uranium business in some form or other, because I had previously been president of a uranium company [while with Vitro] in Salt Lake City. In late 1967, while on a plane going to New York for a business meeting, I started thinking about setting up a uranium brokerage business, and I sketched out a little business plan. Using the predictions we had at that time about the growth of nuclear power in the country, I figured out what the requirements for uranium would be, and it was apparent that it was a growth business. I started talking about it with a fellow named Payne Kibbe, whom I'd known on and off over the years and who was interested in that sort of thing.

NUEXCO: Were there any uranium brokerage firms in existence then?

GW: No, definitely not. At that time I was, in my capacity at GE, occasionally buying uranium for some of our customers when they would ask for help. In those days, you could try to buy so many thousands of pounds of uranium, and one day you might pay eight dollars a pound for it and the

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next day you might pay six dollars or seven. There was no standard at all — it was just a free-for-all negotiating thing — and it struck me that there was a place for somebody to come in there — be a trader — and establish a market.

About this same time, (and unbeknownst to me), Payne, who had been president of a uranium company [Atlas Corporation] and was very interested in the financial side of the uranium business, had an idea about setting up a company which would trade in uranium, but not as a broker. He envisaged it as a bank where people who had overpurchased could deposit their uranium, and people who had underpurchased could borrow it, paying interest to the bank. The bank in turn would pay some interest to the depositors.

He and a couple of his associates were preparing to incorporate such a company in, I think it was, March or April of 1968. Shortly thereafter, Payne and I got together and I told him I was going to leave GE. He said, "Well, I've got this idea for a company, but I haven't done anything about it yet. Would you like to come in and we'll put it together on a 50-50 basis?" I said, "Yes, I would", and we did. He said that he didn't think that there was room for brokerage — the industry didn't like middlemen — and so we would incorporate as the Nuclear Bank Corporation, and we wouldn't talk brokerage.

NUEXCO: Was that the name you started with, then? Nuclear Bank Corporation?

GW: Yes, but as Payne tried to incorporate it he found that anything with the name "bank" in it was subject to various state and federal rules and regulations, so it was quickly changed to Nuclear Exchange Corporation. The shortening to NUEXCO came from my wife — she always called it NUEXCO — and we eventually adopted that name.

NUEXCO: How did Bob Wolcott become involved with NUEXCO?

GW: We were looking for another director and I proposed to Payne that we put Bob on the Board. I'd worked with Bob since 1948. He resigned [from GE] a few months before I did to set up his own consulting company.

NUEXCO: Mr. Wolcott, when you were with GE, did you know Payne Kibbe?

BW: No, but I got to know him real well after I became one of the directors of NUEXCO. As I remember, George and Payne were the founders, and Payne appointed two of the directors: Mike Romney and Don Allen from Salt Lake City. I was one of George's appointees from the local [California] scene, if you will. George's other director was Jules Pearlman. So we had a six-man board — George, Payne, Mike Romney, Don Allen, Jules Pearlman, and me.

NUEXCO: When you first were involved with NUEXCO twenty years ago, how did you perceive the future?

BW: We all thought it was going to have a bright future. At the time when we first started in the [commercial] nuclear business, which was 1955, the US growth rate for electric power was seven percent per year, and had been that rate for fifty years, which meant that the whole generating industry doubled every ten years. With that kind of projection we could see that there was a tremendous need for new power generation of all kinds. And at that time, the environmentalists were not a strong force. In fact, the environmentalists thought nuclear power was great — no ashes, it didn't spew a lot of stuff into the air — so we had very good support there. Utilities didn't like coal. But the key at the time was to get nuclear power to be economically competitive with fossil fuels. That was the challenge that we really had to struggle with, because it wasn't that easy to get nuclear power costs down to the same level as oil and gas.

That was the single biggest event that turned on nuclear power — when its costs dropped to be competitive with fossil fuels. In fact, looking back, I guess that was the thing that really got NUEXCO going, because there was, in the early 1970s, a burst of orders for new [nuclear] power plants, and a tremendous concern over how they were going to be fueled, and people rushed out to cover their future commiments with long-term contracts. So there was a flurry of activity in the uranium industry that was far beyond anything that had occurred previously.

NUEXCO: In the early years, how did a nuclear utility go about buying uranium for its plants and getting it fabricated?

GW: Well, you take some of the earliest nuclear utilities, like Commonwealth Edison in Chicago. They would buy a nuclear plant from, say, GE, which probably included the fabrication of the first core and several reloads, then they

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would go out and buy the uranium and the conversion to UF6. In those days, they would buy the enrichment, of course, from the AEC. When they bought the uranium, the utilities would usually go out for sealed bids. They would advertise or they would just write all the uranium producers asking for their best offer for so many pounds delivered at such and such a place, on such and such a date.

When we first started NUEXCO, Payne and I — I guess myself more than Payne — travelled to all the utilities that were interested in nuclear, and proposed that they join the Exchange. They would have the privilege of getting our reports and they would have the privilege of depositing and borrowing, and so forth.

NUEXCO: Did they respond favorably to that?

GW: No. Mostly we were told that they were very smart people. They said, "We are very competent managers, and we don't plan to buy either too much or too little uranium. We are going to buy just the right amount." We would say, "Well, things don't always work out quite the way you expect them to. Sometimes you have fuel failures and you have to have a replacement, or something else goes wrong. It's pretty hard to believe that you can be that accurate."

What we did, finally, was to convince a fellow named Bill Webster of New England Electric [to join]. He said he would join for a year, and he would use his best efforts with the Edison Electric Institute to see that we got enough subscribers to make us viable, and he was as good as his word. We got ten or twelve utilities, which at that time was pretty good.

NUEXCO: Was that enough to make the business start up and go?

GW: Oh, it paid the rent and a few other things. I guess it was almost a year before we made our first transaction, which was when Cotter Corporation [now a wholly-owned subsidiary of Commonwealth Edison] borrowed a hundred thousand pounds of uranium — at least that's my recollection. I think they borrowed it from a US utility that had too much on hand. It was a deal something like that, and that was very exciting.

Then something came to pass which really was the most important aspect of all of this. And that was, in signing a contract, the borrower had to agree to pay back the same amount that he borrowed. But here again, you can never return the exact same number of pounds you borrowed — you'd be a drum heavy or a drum light and there might be as much as a thousand pounds of uranium more or less than you'd borrowed. And what was that worth?

So we established an "Exchange Value". We did that very early in the game to reflect our view of the market. And, of course, that was what made NUEXCO go, because before long everybody wanted to know what the Exchange Value was for the next month, and so they all started subscribing. And first thing you know, somebody said, "Look, you know what's going on, we need a million pounds of uranium next year — why don't you buy it for us and we'll pay you a little bit to do it." An then, of course, the brokerage end of the thing completely swamped the lending/borrowing end. That's how we got from there to here. We really developed the brokerage end of it.

NUEXCO: How do you think the industry viewed NUEXCO setting up as a brokerage house?

BW: It was not the original intent of the company to be a brokerage operation and, for a long time, Payne was very much opposed to calling it a brokerage operation or identifying the people [NUEXCO] as brokers. He was interested in calling them almost anything but brokers because he said, "If you go to a utility and say, 'I'm a broker', you won't get through the door." But the business emerged into brokerage without being called a brokerage operation. It was still developing as a bank, but then opportunities came along to sell uranium or buy uranium.

NUEXCO: So utilities didn't like brokers?

BW: No, the utilities didn't like brokers.

GW: Well, it's not until you become a broker that you realize how much work there is in putting a deal together. You're saving a utility a hell of a lot of money, really. Some of them understand that and some of them don't.

NUEXCO: How about the uranium producers?

GW: They didn't like it to start with. But when they realized that they were getting whipsawed by the utilities they started thinking maybe it wasn't such a bad idea. Of course, that varied. Some liked us and some didn't.

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NUEXCO: Do you think the industry was ready for brokerage at that point?

BW: I would say it must have been. The greatest test of whether something is really needed is whether the market supports its. And the market did support it. NUEXCO really caught on.

NUEXCO: What was Payne Kibbe's involvement in the growth of the company?

GW: Well, we agreed that I would run the operation but that he would feed information to me and we would work together on the business end of it. He was a consultant and he got around a great deal. And, actually, many people have said to me over the course of the years, "George, why did Payne get half of everything here? You're the guy that did all the work." My answer to them was, "Maybe I can't describe quite what Payne did for me, but I can tell you that we wouldn't have a company if it weren't for him."

I guess you really have to have at least two people to make anything go right. There are loners, but I'm not one of them. I was on the phone with him at least once a day. We discussed every move we made, and he was very, very important to me — a wonderful friend and partner. Furthermore, I was well connected mainly with the utility industry, and he was well connected mainly with the uranium industry. Both sides have always been equally important to NUEXCO.

NUEXCO: What were the deals like at first? When did they become more complex?

GW: One of the earliest large contracts we had was with a company who was a very large factor in the business then. The buyer that was responsible for their uranium business called me up and he said, "You say your Exchange Value is six dollars?" (It was in that range.) "We can't produce uranium for six dollars. You're just fooling the whole world."

And I said, "No, if you want us to buy uranium for you at six dollars, just give me an order."

He thought for a while, and he said, "I'll tell you what I'll do. I want my name kept completely out of this thing, but I'll set up so many million dollars in a bank account and I want you to buy for me," I think it was, "three million pounds of uranium, and I'll pay you, maybe, a nickle a pound for it, and you can buy all that at your price of six dollars or less."

I said, "Fine".

And he added, "The only thing is, I'm not going to give you a checkbook with 18 million dollars in your name, so we've got to set up some kind of escrow agreement with a bank."

This turned into a fairly complicated thing, but we bought all this uranium for him. That was the first big use of a broker. And then people started to come to us because they saw we were, in fact, doing business.

Another one of the early deals involved United Nuclear. They needed to borrow a lot of money to open up a new mine or something, and they were having trouble raising the money. And so we said to them, "Look, we know a utility that has several million extra pounds of uranium because their plants have been badly delayed. Why don't you borrow that from them, you can sell it, and you'll get your cash. And the utility will be delighted to lend you that at maybe three or four percent interest, whereas you'd have to pay the bank ten."

Well, they [United Nuclear] thought that was a great idea, and the utility liked it because it got that material off their backs and gave them a little income. United Nuclear was then one of the big producers and the utility felt very confident that there was no problem about getting paid back. This transaction got more complicated because, in addition to arranging the loan, NUEXCO was selling the material for United Nuclear. That would have been about 1973 or 1974. I can remember sitting in a hotel in San Francisco, putting that deal together on the back of an envelope with United Nuclear's treasurer.

Then there were people who had uranium that had already been converted to UF_6, so then you had to work out a scheme to equate UF_6 with U_3O_8. To complicate it further, some people had partially-enriched uranium, so then you had the opportunity of de-enriching and deconverting. These things came about because of the inequities — the imbalances — which Payne and I had foreseen when we started, but they were far more complicated than we'd ever anticipated, and that was better for us.

BW: Part of our strategy was to participate in the more complicated deals, and to leave the simple little deals to the competitors, because we had a worldwide complex and we had more talent working together. We were trying to move into the part of the market where things were more

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complicated and where the value of services was much higher. This is what NUEXCO has continued to do. It's moved up the scale, and by adding in the capability to arrange financing, it has significantly enlarged the services that are provided.

NUEXCO: Was NUEXCO doing long-term contracts as well as spot?

BW: Yes, all kinds. Initially it was more spot brokerage, then it began to get more into long-term contracts as well as spot brokerage. Then after the big price collapse, a major portion of our business was selling off excess inventories held by utilities. Much of this uranium was purchased by producers who had long-term contracts, and who could buy the material more cheaply than they could produce it from their own mines. So we had, at that time, what we called the "upside down market", where most of the deals were from utilities to producers.

NUEXCO: How many brokers did the company have at that point?

BW: Let's see. When I became President of NUEXCO we had Sandy Anderson, George White, Jr., Jim Vaughan, Wayne Fowler, Jerry Reaves, Tom Boyden, Wes Miller, and Lanny Phillips. That was about the total organization — that would have been in 1977. Then we started building up by adding young people. We added a round of young people, that must have been in the late 70s to early 1980s. They included Katie Bowen, Kim Peyton, Scott Hickman, Terry Elms, and Michele Patin.

NUEXCO: Was NUEXCO doing consulting then, too, or was it almost entirely brokerage?

BW: We were doing some consulting, but very little. It was nearly all brokerage.

NUEXCO: During the first few years, was the government apprehensive about the Exchange Value?

GW: I don't think so. At the very beginning, I don't think they took us very seriously — well, nobody did. You know how it is when you're just getting started. But later — I was very well known, having been head of the GE organization, and Payne was well-known by the producers — I think we had the basic confidence of the government people.

NUEXCO: How did people respond to brokers also establishing pricing indicators? Did you run into the situation early on, where people were concerned about a potential conflict of interest?

GW: Oh, yes we did — all the way through.

BW: Naturally, the utilities thought it was high, and the producers thought it was low. But this seemed to me to be natural. I was not unduly concerned about that. We did do one thing because of these comments — we added the Transaction Value. The idea was that, we've got this one value — the Exchange Value — which is a matter of judgment; it's on the leading edge of prices. No, let's add something that's more analytical, that has less judgment in it and trails along based on history, and you can use that as a check on the Exchange Value.

I used to say, "Look, we publish the [Exchange] Value, but how you use it or whether you use it is entirely your business. You're not obligated to do anything with it merely because we publish it. If you want to use somebody else, fine. If you want to use it in a contract, that's your business. We're not urging you to put it in your contract."

I think the Exchange Value did a lot to establish the identification of the name NUEXCO, because people did begin to accept it as an accurate measure of spot market prices.

NUEXCO: When did you begin sending out the first Monthly Reports with the Exchange Value information? Was that from the start?

GW: Yes. The first one — well, I'm embarassed when I look at it — it was really a rudimentary thing, but I managed to get it a little bit better and, in 1970, we hired a fellow named Jack Mommsen. One of the first things that Jack insisted on was that he be given free rein to give us a decent Report. He said, "I'm ashamed of that".

Well, I was so wrapped up in the mechanics of the business and worrying about the money that I wasn't paying enought attention to it, and he had just completed his MBA and had specialized in marketing. That was one of the great things that happened to us — having Jack run the Report.

NUEXCO: Was the Monthly Report a good part of your business at first?

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GW: It was the thing that kept us alive. We built the subscription list, as I recall, to over 400 quite rapidly. It really took off.

NUEXCO: How much did you charge for a subscription?

GW: Well, it was originally a hundred dollars a month if you were a producer or a utility. But Wall Street firms subscribed to it, and they had a special rate. And the federal government — the AEC — finally gave us a bunch of subscriptions to it. We gave them a special rate on that because we wanted to see it around on their desks. And then the foreign people started to get interested in it, and we started to get subscriptions from them.

NUEXCO: What was the uranium market like back in the late 1960s?

BW: Uranium prices were all over the map. The industry was pretty wild, because back at the start the utilities weren't allowed to import uranium. So they all had to buy domestic uranium — one hundred per cent through 1976 — and then it phased down to no import limit. But the whole nuclear business was taking off with a roar, and the big concern was being sure that you had an adequate fuel supply. I can remember that some public utility commissions wouldn't permit the utilities to buy a reactor until they had assured the PUC that they had contracted for an adequate supply of uranium. So there was tremendous pressure on the domestic uranium industry. Then the whole nuclear business went to pot, and the access to foreign uranium opened up, and that reversal really created a chaotic situation for the uranium producers here in the USA.

NUEXCO: So could the utilities drive a pretty hard bargain, or was the market being driven by the producers?

BW: The utilities drove a hard bargain until the industry took off, that is, until the [plant] orders started rolling in. Prior to 1970, there was really very little demand for uranium. There were only a few reactors operating.

Beginning in the 1970s, the projected demand for uranium was tremendous and, of course, US utilities could only buy US uranium. That put a constraint on it, and the price really shot up then. And when the price shot up, that convinced everybody that there must have been some kind of price fixing, and the lawsuits started and the great anti-trust investigation got underway. But I don't think price fixing had anything to do with the price increase.

NUEXCO: That was in about 1973 or 1974, if I remember, when that price curve started going upward.

BW: I came to NUEXCO in January of 1977, and the anti-trust investigation was underway at that time. The whole anti-trust investigation must have started in 1976, but the Westinghouse affair started in 1975.

GW: One of the things that was the most traumatic to me was when Westinghouse overcommitted. They went short on the market and, of course, it drove the price up to — what was it — over forty dollars a pound as I recall. We had a terrible time trying to decide what the Exchange Value was going to be from month to month because it would move three, four, five dollars a month, and everybody was mad at us then. The producers thought it should be even higher, and the utilities would call up and just scream at us, that we were just burglars, that we didn't understand our business. But in hindsight, I'd say that we did it about right. Then, of course, following the Westinghouse case, came the anti-trust investigation.

NUEXCO: Did they subpoena you?

GW: Yes. I spent close to a week in Washington in front of a federal grand jury, as did my son, George. You know, that sort of thing is terribly expensive and I think the whole thing was outrageous.

NUEXCO: Why did Westinghouse get in trouble and not GE?

GW: Because GE didn't sell short. During that period, I was running GE. Westinghouse was selling plants, and part of their competitive stance was to offer to include cheap uranium. Unfortunately, they neglected to make any arrangements to buy the uranium they'd committed to deliver. They were short. And the sales people [at GE] were really beating on me to do the same thing, and I said, "No, sir." I had been in the uranium business and I didn't want anything to do with speculation in the metals markets.

I used to argue that GE didn't have the people, the constitution, or the ability to withstand the pressure when

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things went wrong. And it will. The market's going to go wrong on you sometime. And that's really what happened to Westinghouse. They panicked.

NUEXCO: Did you have any other run-ins with the government?

GW: I think that's the only one. By and large, they were very supportive. DOE used SWUCO [an affiliated company] a lot more than NUEXCO. They thought SWUCO was great because we helped them with their inflexibility, and we allowed customers to gain flexibility. DOE could see the French and others building enrichment plants, and they were faced with a very difficult problem pricing and contracting and handling their SWUs, because Congress was second-guessing them all the time. We gave them flexibility without them having to give it away, which would have been the case if they'd written their contracts to give that flexibility.

NUEXCO: How would you describe NUEXCO's position in the industry during its early years?

BW: It certainly was well-known in the industry and, I think, gained an early niche in it. It was pretty much domestically oriented, partly because there was a fence around the domestic industry. A lot of what happened during the time I was involved with NUEXCO was that it became much more international. Partly that was because some of those barriers came down — there was more buying and selling — and partly because it was obvious that uranium was such a fungible material and was so easily shipped, that it just had to be treated that way.

NUEXCO: When did NUEXCO begin to take part in the international market?

GW: Rather early. I was interested in becoming more international because it seemed to me that, more than anything else, uranium was an international material, since it was very valuable and could be easily transported. It was in the early 1970s — 1972, I think — that we concluded agreements with Nukem and Marubeni [a Japanese trading company] to represent us in Europe and the Far East.

NUEXCO: When you started dealing with different countries, which countries were the first ones?

BW: I think probably the Europeans, and then we did quite a few deals in Taiwan and in Korea, and some in Japan. We were quite successful in Europe. That is why we established the European office.

Back in 1977, we were all in Menlo Park [California], and we only had ten or eleven full-time employees — it wasn't very big. We grew a little bit, and our first office outside Menlo Park was in New York. Jim Vaughan and Katie Bowen went back to establish that office in late 1981. Then the business in Europe developed a little, but we felt there was more potential if we had some people on the scene. In the fall of 1982, Jim and Katie moved over to Europe from New York.

NUEXCO: What was the next stage, then, for NUEXCO?

GW: It was a little complex. In 1972, the AEC came out with a new form of enrichment contract, a fixed commitment kind of contract. And as soon as I read about that I thought, "Boy, there's a place for brokers", and we formed a company called SWUCO.

Payne and I decided that we would make it a subsidiary of NUEXCO — we would separate the two functions — but we needed some money to get that started. We got some money from Nukem and Marubeni, but SWUCO's funding came mostly from NUEXCO and its shareholders. Initially, it was not a happy arrangement because SWUCO didn't do very well. It kept losing money, and we couldn't seem to make a deal.

But later Walt Wolf hit upon a clever scheme of assigning excess SWUs to utilities and, at the same time, having those same utilities cancel some of their previously committed SWUs at no charge. After he put the first one of these deals together — and it was so successful and everybody made money — we were innundated with business. Of course, Walt then had a lock on the market.

NUEXCO: Why did SWUCO split off and become a separate entity?

GW: The fundamental reason was to allow Walt and SWUCO to focus on the SWU business. Walt was the key to SWUCO's success, and initially we saw SWUs as separate and distinct from NUEXCO's uranium business. That, of course, changed over time.

BW: You know, SWUCO was actually established by George and Payne, but Walt advocated an independent

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SWU business. What we didn't really do — Payne, George, and I — was look far enough down the road. At one time SWUs were over here, and uranium was over there, so we were widely separated in totally separate businesses. But then as you began to build up enriched uranium — there was a big inventory of enriched uranium — who's going to handle the enriched uranium? Well, to us at NUEXCO it didn't make any difference whether the uranium was 0.7 percent U_{235} or whether it was two percent or five percent. But then, utilities began to change and they began to think more in terms of the total problem. So the utility buying practices began to involve buying SWUs, enriched uranium, natural uranium swapping, and one thing and another, and the businesses got very much intermixed. As it turned out, after the ownership interests of NUEXCO and SWUCO were separated, NUEXCO became extremely active in the SWU market also, and the two companies were in competition with each other.

NUEXCO: Do you have any comments, now that SWUCO and NUEXCO are back in the same hands?

GW: Well, there's more competition in the business now, and it would seem to make sense to have a stronger, integrated organization which can handle all types of transactions.

NUEXCO: Do you have any closing thoughts that you'd like to leave us with?

GW: Well, one other thing I can say. . . Payne and I had a whole lot of ideas for this company. But the thing we really wanted to get into was the financing. We made a number of trips to Wall Street. Both of us were pretty well connected there and, you know, we never were able to swing anything. We just didn't have the financial muscle to do it. But Mr. Benton has added that financial and financing capability which is great.

I ran into a fellow a couple of years ago — an old friend who had been chairman of a US utility — and we were talking about the business, and he was talking about NUEXCO and how he though it was very clever. And I said that I thought I had been very lucky in how things had worked out back then.

And he said, "No, you were in the right place at the right time with the right product, and you can only hit that about once in your life, and you'd better take advantage of it." And you know, I think that's right. Had we started NUEXCO earlier, I don't think it would have flown at all, and if we'd waited much longer I'm sure someone else would have gotten into the act ahead of us. As it was, we had the field really all to ourselves for a long time — it was just amazing.

BW: It's interesting to look back, as we wind up our discussion on the twenty-year history of NUEXCO, which has always adapted to whatever the market required, while at the same time moving the business forward. Those twenty years can be divided, more or less, into three eras.

The first was the period in which George and Payne established the company, shaped it to a market that would support it, and gathered a nucleus of staff.

The second era emphasized building upon the foundation previously established by developing people—especially young people—, expanding the organization and the range of talents and client services, and becoming more international. But it later became apparent that NUEXCO needed a new dimension if it were to develop its full potential.

That dimension was provided when Oren Benton, an entrepreneur, bought the Company, adding creative financial capability, financial resources, and a new spark to the organization. Now in the third era, NUEXCO has the capability to increase what I term "nuclear fuel market liquidity"—NUEXCO can facilitate distribution of nuclear fuel, investments, and commitments more effectively. The way has been opened for more NUEXCO-contributed value to marketplace needs, and, at the same time, for further growth and expansion.

This third era, of course, is not the end. My experience has been that the NUEXCO business planning horizon is only two or three years, so I don't try to look too far ahead. Nevertheless, we can be confident that there will be a fourth era, a fifth era, and more. I do not know what or when the next stage will be, but I am confident that NUEXCO will continue to adapt, prosper, and take another step up the ladder as new needs and opportunities evolve. ■

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NUEXCO Monthly Report
Number 1
September 1968

Reprinted below is the cover page of the first NUEXCO Monthly Report and page three, the last page of the report, showing market values for September 1968. Yellowcake and UF6 deposits and loan requests were shown on pages one and two of the Report.

Cover Page

N U E X C O

Report No. 1

Date 9-9-68

Category I - Yellow Cake

Ia - Deposits

Ib - Loan Requests

Category II - Natural Uranium Hexafluoride

IIa - Deposits

IIb - Loan Requests

Exchange Values

IIIa - For loans made after 1-1-71

IIIb - For loans made prior to 1-1-71

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Page Three

N U E X C O

Page IIIa
Report No. 1
Date 9-9-68

Exchange Values for Loans Made After 1-1-71

1. Use charge payable to Depositors: 5.5%

2. Settlement Values

Delivery Dates	$/lb U_3O_8	$/lb $UinUF_6$
1/1/71	7.30	9.95
1/1/72	7.60	10.35
1/1/73	7.90	10.75
1/1/74	8.20	11.10
1/1/75	8.50	11.50

3. Loan Values

Delivery Dates	$/lb U_3O_8	$/lb $UinUF_6$
1/1/71	6.95	9.45
1/1/72	7.20	9.85
1/1/73	7.50	10.20
1/1/74	7.80	10.55
1/1/75	8.10	10.90

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THE BEGINNINGS OF THE URANIUM INDUSTRY — A HISTORY

Introduction

This article presents a brief overview of the uranium industry from uranium's discovery in 1789 until the 1940s. A brief caveat concerning the figures presented here is in order. Many published accounts of this period contain highly conflicting figures regarding uranium ore and concentrate production, uranium prices, and radium output. The figures contained herein are NUEXCO's best estimates.

The Discovery of Uranium

In German they are called the Erzgebirge — the ore mountains — a low range between Germany and Czechoslovakia that for centuries has yielded a rich harvest of diverse metals. Ore found near the village of Sanct Joachimsthal in 1519 was used in the first silver coins which were called Joachimsthaler. Soon, these coins became known simply as "thaler" and by 1600, they had become "dollar" in English.

In 1789, a German apothecary named Martin Klaproth succeeded in isolating a grayish metallic substance from a peculiar ore occasionally found in working the nearby Joachimsthal mine. The ore — heavy, velvety black or brown, brittle in fracture and relatively hard — was found in fissure veins and occurred in sections varying from the thickness of a knife blade to several inches in width. This was pitchblende, later labelled uraninite. To honor the German-born British astronomer Sir William Herschel's discovery eight years earlier of the new planet which Herschel had named Uranus, Klaproth called his metal uranium.

Not long after Klaproth's discovery of uranium, experimenters found that its compounds acted as good coloring agents in ceramic glazes. At concentrations of 0.006 percent, the chemical produced a yellow color and, with successively higher concentrations produced orange, brown, green, and a rich, velvety black that was much prized. The forests surrounding Joachimsthal supported one of the centers of ceramics and glassmaking in Europe, with their plentiful supplies of wood for charcoal, and miners began to collect pitchblende residues on a small scale from slag heaps and from the active workings at the Joachimsthal mine. The ore was rich in uranium, averaging 45 to 50 percent U_3O_8 and occasionally assaying as high as 80 percent.

An Industry Takes Shape

The demand for uranium, though not great, nevertheless attracted the atttention of miners in other countries, and discoveries of small quantities of pitchblende began to be reported in France and in England. In Cornwall, lumps of pitchblende were found in discarded ores from tin mines, and soon after were reported from several operating mines. Throughout much of the second half of the 1800s, the English mines were almost the only competitors to Joachimsthal for supplies of pitchblende, although mines in Saxony and in Hungary also contributed small amounts of ore.

While it is difficult to estimate the actual quantity of pitchblende ores taken from the Joachimsthal mines during the 1800s, the total production of this mineral from Cornish mines has been estimated as approximately 325 long tons between 1856 and 1900. This corresponds to perhaps 150 tons U_3O_8 equivalent. Although quite small by today's standards, this quantity, in combination with the Joachimsthal production which was at least as great as that of the English mines, satisfied the demand for uranium.

As new applications for uranium compounds were found, demand slowly increased. By 1900, uranium salts were used not only in ceramics and glassmaking (see yellow sidebar), but also in photography (uranyl salts are sensitive to light) and in steelmaking, where new alloys containing uranium carbide appeared to offer much promise (see yellow sidebar). Of the uranium being produced in the USA, by 1900 virtually the entire output was exported, chiefly to France, where steelmakers in particular were excited about the potential military uses of "ferro-uranium", as it was called. Uranium was quickly becoming an international commodity.

Discoveries in the USA — Colorado

The earliest reported discovery of uranium in the USA is generally thought to have been in Colorado by Dr. Richard Pearce of Denver. Dr. Pearce reported the finding of pitchblende in the Wood Mine near Central City. Later, pitchblende also was found in other nearby mines. Market conditions at the time were such that the pitchblende ore procured by Pearce glutted the market, and it was not until some years later that he sold much of the original material — entirely in England and France.

The discovery of another uranium-bearing mineral called carnotite proved to be of considerably greater long-term significance.

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Figure 1. An early freight outfit. (Reprinted from *Uranium Country*, 1955, University of Colorado Press.)

Although the yellow mineral was known to have been collected by Indians prior to 1880 (for use in war paints) in La Sal Canyon, Colorado, probably the earliest documented discovery of carnotite can be attributed to Tom Talbert. In 1881, Talbert staked a claim at Roc Creek in the Paradox Valley, but the elements in the mineral discovered were not at that time identified. Talbert's claims were later relocated several times and, in 1898, Gordon Kimball leased the property. According to a letter sent by Kimball in 1904 to the Engineering and Mining Journal:

"In 1897 I met, in Denver, a French chemist named Charles Poulot, who was in the market for ores containing rare metals, especially uranium ores, and through him learned to distinguish the various compounds of that element. I had long been familiar with certain deposits on Roc Creek in the extreme western part of Montrose County, Colorado, that had been located many times for copper values. . . . I learned that quite a large deposit of yellow minerals, called by the owner chrome copper ore, had been exposed in one of these claims several years before. In the spring of 1898, I obtained samples of the "yellow stuff" and sent them to Mr. Poulot who pronounced them uranium ore and gave the mineral the name of autonite or uranochre.

. . . In June 1899, I mined ten tons of ore (practically all from one pocket), sacked and packed it in burros across the mesa to Paradox Valley, a distance of twelve miles. From there it was shipped 80 miles by wagon to Placerville, and thence to Denver by rail where it was sampled and sold for $2,600, or at the rate of $12.50 per unit. The entire lot averaged 21.5 percent oxide contents. This ore also carried over fifteen percent vanadium, for which our purchasers in France, on resampling the shipment, exacted a penalty instead of allowing value. . . It is not improbable that it was one of these specimens which, on analysis, was found to contain radium, and was named after the eminent scientist, M. Adolphe Carnot."

As word spread that the uranium mineral was marketable, other discoveries also were reported, although not as quickly commercialized as the one at Roc Creek. In 1898, a discovery was reported in Grand County, Utah, just southeast of the Colorado River. In 1899, Ike Hallet noted a carnotite vein about two miles north of the present-day town of Uravan, Colorado at the Salt Lick claim. The same year, the mineral was found in the McIntyre (Dolores) River canyon and some carnotite ore was mined from the Yellow Bird Mine in La Sal Canyon. In 1900, sheepherders found uranium and vanadium mineralization in the Green River district of Utah.

Mr. Poulot and a colleague began experimental work with the new ore, and in late 1899 or early 1900 formed a new company to deal in uranium. After shipping several loads of crudely concentrated uranium-vanadium ore to France, Poulot built an experimental three-stage mill near the Slick Rock area. The mill reportedly had a ten-ton Krupp ball mill, three leaching tanks of about ten-foot diameter, and

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Table 1
URANIUM ORE GRADES IN COLORADO IN THE YEAR 1900

Quantity (lbs ore)	Grade (Percent)	Percent of Total Ore Mined
16,650*	15-16	5.4
90,000	10	29.3
60,000	6	19.6
140,000	5	45.7

* Includes some pitchblende ore mined in Gilpin County.

upright boiler and three tall precipitation tanks. By one account, the mill cost about $8,000 and processed altogether about 355 tons of carnotite ore, yielding some 15,000 pounds of uranium oxide before work was discontinued in 1901. Several other companies operated the mill briefly over the next few years.

Market Conditions at the Turn of the Century

Although the market for uranium around the turn of the century was limited, the relatively high prices paid for ore stimulated considerable interest from inquisitive prospectors and mineral speculators. In 1900, carnotite ore having approximately ten-percent U_3O_8 content could be sold in Denver for between $500 and $550 per ton, and partially-processed concentrates were worth between $2.25 and $4.00 per pound. Ore production in Colorado rose from about seventeen tons in 1897 to 33 tons in 1898 to 43 tons in 1899. According to official statistics, by 1900 production had surged to 153 tons of uranium ore. By contrast, production of pitchblende ores in England measured seven long tones (2,240 pounds) in 1899 and 41 tons in 1900, and Austrian output of uranium ores (pitchblende from the Joachimsthal mines) probably was between 10 and 30 long tons respectively in 1899 and 1900.

Although the average grade of the carnotite ore was generally lower that that of pitchblende, it was available in vastly larger quantities and was accessible by surface mining. (Carnotite has a distinctive canary-yellow color, and generally occurs layered in sandstone.) Of equal or greater importance to miners of the day, carnotite contained significant amounts of vanadium, which was gaining in demand as a steel alloying mineral and as a coloring agent for the dying of silks.

For the first few years, the carnotite ore removed from the Paradox Valley and other nearby areas was of high grade. Some of this ore contained 15- to 20-percent uranium and occasionally a shipment might run as high as 45-percent uranium. Since the ore had to be packed into bags and freighted in wagons some 40 to 70 miles to the nearest railhead, it was carefully hand sorted and only the better grades were deemed worthy of handling. In part, this reflected the attitude of European buyers who represented the market and who, for a number of years, were not interested in any ores with less than three to five percent U_3O_8 content. Also, production costs had to include freight from a remote valley in eastern Colorado to the east coast of the USA, and then transshipment to Europe.

Until perhaps 1902, there was little digging underground for uranium ores; the limited demand could be met by carefully following known surface deposits and picking out the richest specimens. Table 1 shows the range of ore grades mined in Colorado during 1900.

By 1903, the steadily increasing production from Colorado had had its effect in Europe. The last remaining pitchblende source in England, the mined-out South Terras property in Cornwall, ceased production of uranium in 1902. (A decade later it was revived when market conditions brought new demand.) It appears that pitchblende output at Joachimsthal also was considerably curtailed. A new market for uranium ores, however, was about to open up, transforming the tiny uranium industry and making uranium a subject of everyday conversation in many areas of the world. That new market was to become known by one word — radium.

"Radium completely neutralizes the poison of the viper, on 50 to 60 hours exposure." (E&MJ, April 1905)

The Most Expensive Substance in the World

More than a decade elapsed between the discovery of radium in 1898 by Marie and Pierre Curie and the

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development of an efficient, commercially-viable process to extract it. During this period, a wide variety of claims were made about radium's miraculous properties, and a great deal of public attention was paid to a substance which, as yet, had little practical use.

In the mining industry, radium's newfound status focused renewed attention on uranium, although for several years after 1900 it was not clear how, or if radium was connected to uranium. While the earliest samples of the new element had come from processing uranium ores, it was not until 1904 that Bertram Boltwood demonstrated that "the percent of radium in a mineral appears to vary directly as the percent of uranium present". Boltwood fixed the ratio at one part radium per 1,350,000 parts uranium. This discovery created a new market for uranium that soon grew far beyond the earlier market, which had depended on uranium's limited use in glassmaking, ceramics, and steel.

As early as 1903, mining journals had begun to discuss radium in some detail, and the little-understood physical properties of radioactivity were subjects of much interest, as well as many misconceptions (see grey boxes).

By 1904, the "pitchblende excitement" had prompted the first public promotion of a radium mine. A company called Uranium Minerals Ltd. was formed in London with a reported capital of $300,000 to purchase and work the Thors mine in Norway. One journal correctly called this venture a "doubtful enterprise".

At the time, radium production was being carried out solely by the Société Centrale des Produits Chimiques of Paris, using pitchblende ores. However, as the Austrian government placed an embargo on the export of pitchblende from Joachimsthal, interest turned to the possible commercial-scale extraction of radium for carnotite, which was available from mines on the Colorado plateau.

Throughout the world, prospectors began actively seeking radium-bearing ores. In 1904, prospectors found a specimen containing over 70-percent uranium at Lake Pied des Monts, near Murray Bay in Quebec. The Canadian government, a few years later, paid a bounty for the discovery of uranium-bearing ore specimens.

In Cornwall, England, where pitchblende had long been found but where its mining and collection from waste dumps had but recently been largely discontinued, the excitement over radium caused a new rush to look for the ore. Within a few years, the demand for pitchblende was such that streets in several towns were dug up to recover pitchblende that had been discarded from tin mines years before. A mining journal commented in 1909 that "the richest prize in the mining world is a vein of pitchblende ore".

By 1906, carnotite ore had been reported, in addition to the now numerous claims in Colorado and Utah, from Olary in South Australia. This area, which became known as Radium Hill, subsequently went through a prolonged period in which overzealous claims about its reserves, as well as poor business practices, made it a much talked about, but only minimally-producing uranium area.

By 1909, various types of uranium minerals had been reported in several other countries as well including Sweden, Norway, and Portugal. In Sweden, a radium-producing concern was started in a suburb of Stockholm by the Kolm Company to process ores from a property at Billingen. ("Kolm" is a type of coal occuring in alum schists in Sweden, which was believed to contain about two-percent uranium). Near Tvedestrand, Norway, miners reported finding uranium ore reportedly containing over 60-percent uranium in old apatite and feldspar workings.

In Portugal, a British company took a concession to develop several uranium claims that had been discovered years earlier. In contrast to the Swedish and Norwegian sites, these properties in Portugal soon began supplying a regular stream of good-quality ore into the market, and continued to be actively mined for many years. Their ore went almost exclusively to France.

"This time it is argentiferous radium which bears the brunt of a presuming novelty. Our lively trans-Atlantic contemporary, L'Echo des Mines de la Metallurgie, notes as a brilliant Italian invention an alloy composed of copper, iron, silver, phosphorous and radium. The result of this wild alloying of old comrades is a 'metal harder than steel, as brilliant as gold, from which it cannot be distinguished, and as good a conductor as copper'. But better than this, for it bears the stamp of the best medieval alchemy, this 'argentiferous radium' weighs less than copper, and changes not its beautiful color with any physical or chemical agent. The name of the thrifty patent owner is coupled with the greatest of European bankers. It is interesting, if true. We will go further — it is interesting if only half true." (E&MJ, May 1905)

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URANIUM AS A GLASS TINT

Uranium's first known commercial application was as a coloring agent in the manufacture of glass and ceramic glazes. In 1826, Josef Riedel's glassworks in Bohemia introduced a new line of green and yellow glass made with uranium called "Annagrun" or "Annagelb" after Riedel's wife Anna. The unusual iridescent green and yellow tints produced by the recently discovered element became very popular and, by the 1830s, "Anna" glass was in commercial production. The nearby Joachimstal mines provided the uranium from pitchblende ores.

By 1843, a French glassworks at Baccarat was offering yellow and green-tinted glass made with uranium oxide which they called "cristal dichroide". Soon afterward, they introduced an opaque green glass known as Chrysoprase, again using uranium to produce the color. In England, the firm of Lloyd & Summerfield also began offering uranium-colored glassware.

In 1885, the Mt. Washington Glassworks in Boston (USA) began producing "Burmese" glass, which had characteristic salmon pink and lemon yellow tints. The uranium oxide used in this glass was worth about $1.00 per pound in 1885. The glass's formula was also used for a set of glassware presented to Queen Victoria and Princess Beatrice which became known as the "Queen's Design". Although other American glassmakers used uranium, the Burmese glass become one of the best known of such products.

By the early part of the twentieth century, uranium glass began to decline in popularity. It did, however, find a brief application in the manufacture of the bright yellow automobile headlamp lenses that were fitted to some cars between 1915 and 1930. This glass required as much as 30-percent uranium oxide to attain the desired color, and was rather expensive to produce. Even as late as the 1960s, uranium was occasionally used to make scientific glassware that required certain optical or chemical properties.

In addition to its use in glassmaking, uranium salts were used to color ceramic glazes. Uranium-based glazes also enjoyed some popularity in architectural ceramics; their mild yellow color may still be seen in Europe on facings and borders of buildings.

Although demand for uranium ores did increase with the excitement over radium, the early radium extraction processes were inefficient. From 1900 to 1910, ore prices remained relatively constant, although radium prices escalated rapidly.

Advances in Radium Production Technology

Production of commercial quantities of radium required the development of more efficient processes for refining radium from its host ore. The initial extraction processes were largely scaled-up versions of the Curies' original techniques. However, in 1909, Sir William Ramsay, a chemist associated with the British Radium Corporation, succeeded in extracting a small sample of radium using his own process, which reduced production time of the desired end product — purified radium chloride or bromide — from as much as a year to a few weeks. This advance in chemical technology made possible a rapid increase in worldwide radium production, and allowed radium to be extracted from lower-grade, previously uneconomical ores such as carnotite.

> ***"Even if a store of radium should be found the extraction of the substance will be a great difficulty, as merely to enter a room containing two pounds would probably destroy the sight, burn off all the skin on the body, and quickly kill." (Mining and Scientific Press, March 1903)***

By 1910, in addition to the French factory and the Imperial Austrian radium works at Joachimsthal, the British Radium Corporation had become an active supplier of radium, and was in turn buying Colorado carnotite ores. The value of the ore was from $100 to $300 per ton in uranium and vanadium. At the time, freight from the Paradox Valley area cost about $20 per ton to the railhead at Placerville, Colorado, and then about $13.50 to Europe.

The steadily increasing worldwide demand continued to drive up prices for the small available supply of radium, whose only use was for largely experimental medical treatments and scientific experiments. By 1911, the selling price for the pure radium equivalent (it was typically sold as radium bromide, containing 53.6 percent radium) had reached $120,000 to $160,000 per gram. Radium "banks"

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were established in Paris and London to loan small quantities at the rate of $200 per day. Radium was the most expensive commodity of its day, and speculators and market observers awaited even higher prices.

> ***"In a recent issue of Vanity Fair we read an announcement. . . to the effect that a golf ball with amazing proclivities is now for sale. When hit, we are told, 'the radium salts in the plastic center start a wave of momentum which gives it a great resiliancy. The ball literally is alive, and the released energy actually fights to free itself. Hard hit — it races yards farthest.' Thus we learn that the game does not necessarily go to the adept, to the strong, or to the experienced, but to the one who can afford to patronize a high-class store to buy the ball with radium salts in the center. Alas for golf as a sport." (E&MJ, December 1922)***

Radium Production in the USA

In the USA, growing radium imports were causing much concern. It was not until 1913, however, that industrial-scale radium production commenced in the USA. The first commercially-available pure radium salt was produced from Colorado carnotite ores by the Standard Chemical Co. in Pittsburgh, Pennsylvania. The firm's orders from Europe immediately greatly exceeded its initial capacity of one gram radium per month. Soon after, the Radium Company of America also began operating a production facility in Pennsylvania.

As the Pennsylvania plants had easy access to much greater quantities of ore than did European producers, the USA quickly became the leading producer of radium. In 1913, the Standard Chemical Co. reported production of between 12 and 13 grams of radium equivalent, requiring a minimum of about 3,000 tons carnotite ore. (Assuming 100-percent recovery, it takes about 215 tons of two-percent U_3O_8 ore to produce one gram of radium.)

URANIUM-STEEL ALLOYS

During the late 1800s, European steelmakers began experimenting with uranium as an alloy in steel. The first experiments appeared to offer a bright future for these alloys and, in 1900, an article published in the mining press noted that:

"the tendency of modern engineering leans toward the production of alloys of the rare metals instead of the metals themselves, a circumstance which has led to the development of a peculiar industry aiming at the manufacture of a great number of metallic alloys, among which the undetermined compounds of uranium and steel play a significant role. Especially in France, the beneficial effect produced by the addition of a small percentage of uranium carbide to steel has been realized, so that an extended manufacture of war material from that alloy has sprung up there in the last two years. It seems that a compound of this kind surpasses any other product obtained by mixing and incorporating ferro or carbon alloys with fluid steel, as it increases the tensile strength, toughness and elongation of that substance remarkably."

This early enthusiasm about uranium's properties as an alloying agent, however, soon gave way to a more realistic view. One reason that steelmakers' interest in uranium had declined was the growing success of vanadium-steel alloys, which offered much greater improvements in strength and hardness and which were vastly easier to manufacture than those of uranium.

In addition to experiments conducted by the French navy, the Krupp steelworks in Essen, Germany had by 1907 carried out trials using ferro-uranium fabricated into steel plates for ships. This material, however, offered insufficient improvement over cheaper, more easily fabricated steels, and its military use never really reached the production stage.

By 1916, metallurgists had begun to test uranium alloys in a more systematic way. A comparative test published in *Iron Age* showed uranium-steel tools outperforming regular high-speed steels by a considerable margin in controlled drilling. However, the difficulties in making ferro-uranium a commercially-viable material also were becoming obvious. One major problem was controlling the percentages of carbon and uranium in the final product. Although some further testing did follow, uranium subsequently found little application in steelmaking.

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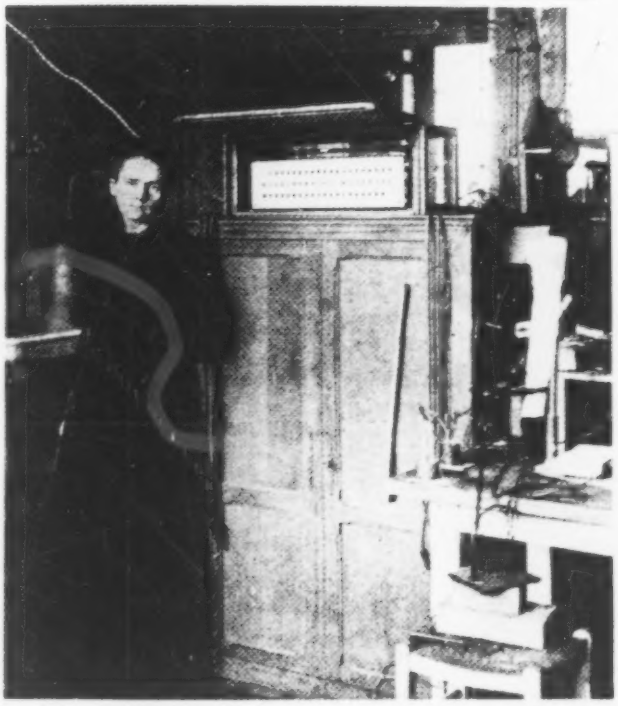
The increased demand for uranium ores was rather evenly matched by increased production, and prices for ore remained steady or increased only slightly. Between 1912 and 1914, US uranium production increased from about 58,000 pounds U_3O_8 equivalent to about 174,000 pounds. Prices for two-percent ore were around $2.00 per pound of contained U_3O_8. In England, output of pitchblende ore increased even more dramatically, even though its production had been highly erratic for some years, rising from 42 longs tons of ore (containing approximately 35,000 pound U_3O_8 equivalent) in 1912 to 344 tons (with about 300,000 pounds U_3O_8) in 1914. Nearly half of the US uranium ore production in 1913 was exported to Europe.

The Uranium and Radium Markets - 1914 to 1923

From the beginning of World War I in 1914 to 1922, US uranium and radium producers virtually controlled the world market. Large increases in production could not come from European producers, whose pitchblende deposits were already strained, and the upheaval and devastation caused by the war had disrupted much of the industrial and labor infrastructure in Europe. However, by 1923, US production of both uranium ore and radium had practically ceased. The reason was the entry into the world market of a production giant, whose large reserves, high ore grade, and low cost of production quickly made it almost the sole competitive source for uranium materials. This giant was the Union Miniere du Haut Katanga, a British-Belgian syndicate operating mines in the Belgian Congo.

At first, the outbreak of war in Europe had little effect on either worldwide radium demand or uranium production. Carnotite from Colorado and Utah had become the primary source of uranium for radium production (other uses for uranium ore were, by comparison, minimal), and US radium manufacturers were making as much as 90 percent of the world supply.

By 1915, US uranium ore production had slowed almost to a halt because of the sudden drop in European demand, but as the war dragged on, US uranium output again increased. From about 175,000 pounds U_3O_8 in 1915, output rose to about 212,000 pounds in 1918 (with a high of 268,000 pounds U_3O_8 in 1916). US radium production had, by the beginning of the war, just become fully commercialized, and rose from 2.1 grams (pure element equivalent) in 1913 to 13.6 grams in 1918. Radium prices maintained a high level, but as rising US production began to influence the market, prices began dropping somewhat and averaged around $120,000 per gram. Demand remained strong, aided by a new application for radium compounds — in "self-luminous" paints.



Madame Curie in her laboratory, 1912. (Reprinted from *Madam Curie, A Biography*, 1939, Doubleday, Doran & Company, Inc.)

Radium began to find a military use during the war, as self-luminous radium paint was used on rifle sights, inside rifle scopes, and on watch dials and other types of instruments to avoid the need to provide lighting during the night, which might betray a soldier's presence to the enemy. The demand for the luminous watch-dial alone raised one use for this material to a fair-sized industry.

The British Admiralty issued a specification for such paint that required 0.4 mg of radium bromide per gram of zinc sulfide. The radium would, however, rather quickly exhaust the zinc sulfide, and within a year would have only about half of its original luminosity. The higher the percentage of radium, the shorter the life of the sulfide.

By 1917, "radium signs" and other such articles painted with luminous paint were becoming fairly commonplace, at least in the USA. A Denver, Colorado company called the Cold Light

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EARLY THOUGHTS ON NUCLEAR PHYSICS AND URANIUM

The 1890s were a time of unparalleled excitement and rapid discovery in the physical sciences, a bright new age in which scientists struggled to understand the forces and structure of the most elemental particles of matter. In November 1895, Wilhelm Röntgen discovered mysterious rays emanating from the fluorescing glass walls of a cathode ray tube — X rays. A British scientist, J.J. Thompson, at once sensed the importance of Rontgen's discovery, and began to study these unusual, highly penetrating rays; his own work with cathode rays and then X-rays culminated in his identifying, in 1897, the first sub-atomic particle — the electron.

Rontgen's X-rays also fascinated other researchers. Henri Becquerel, a leading expert in the study of phosphorescence and fluorescence in France, was especially interested in uranium. When he heard of Röntgen's work he immediately began to test a variety of fluorescing materials for X-rays. After several unsuccessful experiments, Becquerel decided to try a uranium salt — uranyl potassium sulfate.

Becquerel immediately found that the uranium compound emitted a type of radiation. When he developed a photographic plate on which he had sprinkled a layer of uranium salt, it showed a silhouette of the phosphorescent material. However, as he had exposed his sealed photographic plate to the sun for several hours, he mistakenly thought the sunlight had activated the effect, much as the cathode rays had activated Röntgen's X-rays.

When Becquerel tried to repeat his experiment, Paris was overcast, so he put the sealed photographic plate in a drawer, uranium salt still in place. When he developed the plate a few days later, instead of a nonexistent or very weak image, Becquerel was surprised to find an image of great clarity. He had discovered the phenomenon which Marie Curie in 1898 had named radioactivity.

At the time, many of the world's most eminent physicists and chemists were struggling to comprehend the inner structure of the atom. To scientists such as Ernest Rutherford, Frederick Soddy, Marie Curie, and others, the discovery of radioactivity opened the door to this world. In 1899, Rutherford published results of his experiments, revealing ". . . at least two distinct types of radiation — one that is very readily absorbed, which will be termed for convenience the a (alpha) radiation, and the other of a more penetrative character, which will be termed the b (beta) radiation."

Working with thorium, Rutherford and Soddy soon discovered that it released a radioactive gas which eventually proved to be chemically inert argon gas. This observation of the spontaneous disintegration of radioactive elements was one of the fundamental discoveries of twentieth-century physics. The two scientists later described how uranium, radium, and thorium transmuted into different elements by radiating away part of their mass as alpha and beta particles. This in turn led to the measurement of what came to be called "half-life", or the time required for an element to change half its atoms into that of another element, or a physical variant of the same element. Soddy later termed these "isotopes".

In 1898, Marie and Pierre Curie had purified from uranium ores a new element, possessing an astonishingly intense radioactivity which they named radium. In 1903, after working with radium and other radioactive materials, Soddy published a paper stating that:

". . . the total energy of radiation during the disintegration of one gram of radium cannot be less than 10/8 (i.e. 100,000,000) gram calories, and may be between 10/9 and 10/10 gram calories. . . The union of hydrogen and oxygen liberates approximately 4x10/3 (i.e. 4,000) gram-calories per gram of water produced, and this reaction sets free more energy for a given weight than any other chemical change known. The energy of radioactive change must therefore be at least twenty thousand times, and maybe a million times, as great as the energy of any molecular change."

Soddy also stated that, "The man who puts his hand on the lever by which a parsimonious nature regulates so jealously the output of this store of energy would possess a weapon by which he could destroy the earth if he so chose."

But of all the prominent scientists, it was the Curies who became best known to the public. Marie Curie was one of very few women at the front rank of international science, and her choice of research subjects — the peculiarities of this "emanation" she came to call radioactivity — propelled her, even more than her husband and partner Pierre, into the public eye. From their joint work that produced the discovery of polonium and radium, and then their receipt of the Nobel Prize for physics in 1903 (sharing with Henri Becquerel), the Curies came to represent nuclear physics among the non-scientific public.

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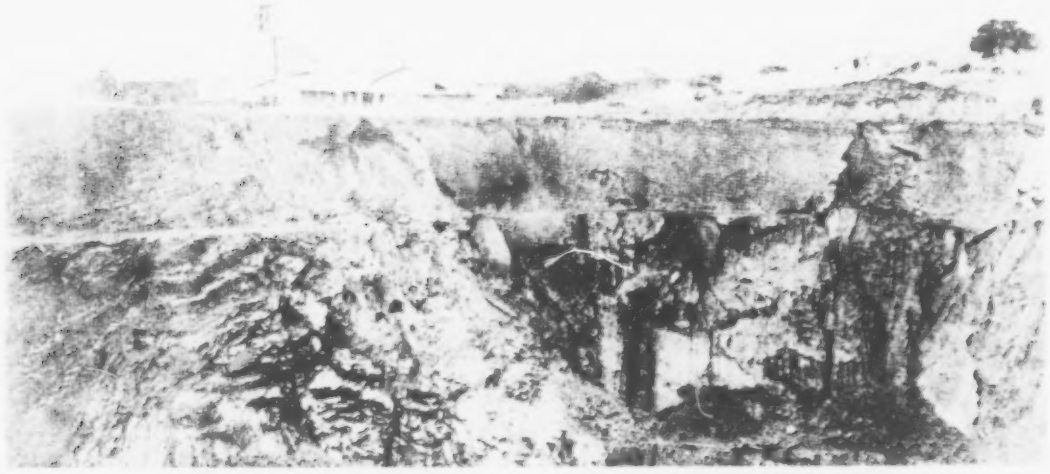

Figure 2. The Shikolobwe Mine. (Reprinted from *Union Miniere du Haut Katanga Monograph*, 1943.)

Manufacturing Co. was organized to manufacture street signs, push buttons, watch and clock dials, and other objects. By the end of the war, an estimated 95 percent of the radium produced was being used in paints, and only five percent in medicine.

The medical uses of radium had gradually become better defined since 1900 when radiation was believed to be a possible miracle cure for many diseases, including cancer. But by 1920, it had become clear that radium's therapeutic uses were limited and quite specific.

Uranium from the Congo

As early as 1913, development work done by the Union Miniere du Haut Katanga at the Luswishi copper mine in the Belgian Congo uncovered an unusual mineralization. Some small veins were found to contain a crystalline, yellow to yellowish green ore, which investigators found contained between 45- and 68-percent U_3O_8. The war in Europe interrupted further investigations at the Luswishi deposit, but in 1915 a similar discovery was made at Shikolobwe (see Figure 2), also referred to as Kasolo. Several types of uranium minerals were found at the two sites, including pitchblende (uraninite), autunite, and carnotite.

By 1921, Belgian experts had been sent to evaluate the deposits, and had immediately recommended their development. The most up-to-date and the largest radium-extraction plant was quickly erected at Oolen, Belgium to treat the ores.

Early shipments from the Luswishi deposit averaged over 60-percent U_3O_8, and the ore was available in far greater quantity than any of the pitchblende ores that had previously assayed at such high grades. Reports give the content of U_3O_8 (from the Congo) at 50 to 70 percent — a staggering figure when compared with two percent ore from Colorado and Utah. The fresh Congo supply meant that US producers were forced from the market almost overnight and, with few exceptions, the uranium mines and mills on the Colorado plateau closed down by the end of 1922.

For the first time since radium's discovery, prices began to drop substantially. Not long after production began in Belgium, radium prices dropped from $120,000 per gram to $70,000 per gram, and by 1923, excess supplies in the hands of US radium producers were being sold as low as $50,000 per gram.

From the first production of radium in 1904 to the middle of 1923 — about 20 years — total worldwide radium production

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was estimated at about 216 grams, with a value of approximately $23 million. The Belgian plant was capable of producing about a third of annual world demand for radium.

The Industry from 1923 to 1942

The Belgian Congo mines continued to control the uranium industry for more than a decade and were only seriously challenged in the mid-1930's when Eldorado Gold Mines began producing uranium as a co-product at its mines in Canada's Northwest Territories. Throughout the 1920s and 1930s, however, new uranium discoveries and claims continued to be announced in many countries.

Uranium-bearing ore was, however, mined on the Colorado Plateau after about 1930, but for vanadium rather than uranium. By 1935, many of the carnotite properties that had been inactive since the early 1920s reopened. Demand for vanadium continued to increase, and the entry of the USA into World War II further stimulated mining of these and many newly-discovered deposits. In 1943, the Union Mines Development Corporation, created by the US government in conjunction with the Union Carbide and Carbon Corporation, began operating mills in Colorado to process uranium ores for use in the government's Manhattan Project, which culminated in the creation of the atomic bomb. From that point on, uranium production in the USA and around the world took on a new charcter, and radium faded from view.

Summary

Two distinct cycles are apparent in the uranium industry's early history. The first cycle ran from the discovery of the element uranium in 1789 to roughly the discovery, then the isolation of radium in 1904. During this period, ore production was small and demand focused on the use of uranium in ceramics and glassmaking, with some late experimentation into using uranium in steel.

The second cycle of uranium production began in 1904 and included the discovery and development of extensive carnotite deposits on the Colorado Plateau, with radium as the desired end product. Uranium compounds *per se* had little use other than the small amounts used in glassmaking and ceramics. By 1923, the Union Miniere du Haut Katanga, had taken over almost the entire world uranium and radium markets, through its control of the lowest-cost and highest-grade deposits in the Belgain Congo. For the next decade and beyond, uranium mining elsewhere in the world was largely nonexistent, and only in the mid-1930s did other producers manage to break the virtual monopoly of the Belgian syndicate.

"Though, at the present time, the whole matter [of radium] is of no immediate practical importance, the material interests of the race are involved in no remote degree. Our present civilization is based on the possession of coal, and the output of mechanical power is increasing rapidly from year to year. In the not very distant future the supply of this indispensable commodity will be exhausted, and unless the human race can find some other source of energy, a relapse into barbarism seems inevitable. Recent experiments at Cambridge go to show that it may not prove wholly impossible to unlock the enormous reserves of internal energy, which, on the hypothesis now under debate, are assumed to be locked up in the atom." (M&SP, reprinted from Engineering, October 1906)

"Uranium has the heaviest atom known, excepting radium, which appears to be a little heavier." (E&MJ, May 1905)

"Radium emanations. . .are classified as follows: (1) The alpha-rays, which are comparatively coarse particles of matter, being about the size of two atoms of hydrogen, carrying a charge of electricity, and traveling at a 20,000 mile rate per second; they have slight penetrating power. (2) The beta-rays are much finer, being only one-thousandth the size of a hydrogen atom; they are identical with the "radiant matter' of Crookes — or the "cathode rays'; they carry negative electricity, and travel at a rate of 160,000 miles per second. (3) The gamma-rays, which are not matter, but only pulses in the ether." (E&MJ, January 1905)

The third cycle in the history of uranium began with the atomic bomb in 1943, yet continues today as uranium finds it primary application in fuel for nuclear-powered electricity. ■

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THE RHODE RANCH PROJECT

Introduction

During the late 1970s and early 1980s, the opening of a new uranium mine in the USA was a common occurrence as high uranium prices provided the incentive for new development. Falling market prices quickly curtailed those openings and only exceptional circumstances have allowed the development of new uranium mines in today's economic environment. Chevron Resources Company and Total Minerals Corporation have combined efforts to develop the first new US open pit uranium mine in almost a decade — the Rhode Ranch project. The components of this project include the acquisition of a top-quality orebody in a district characterized by low-grade deposits; the conversion of a distant mill (84 miles from the deposit) to treat high-alkaline ore; utilization of inexpensive, spent acid from a Chevron refinery; the availability of a well-trained, experienced work force; and limited capital expenditure requirements. Chevron and Total have forged these diverse elements into one of the lowest-cost conventional uranium projects in the USA.

Reasonably-assured reserves at the deposit are estimated at almost seven million pounds U_3O_8. Mining commenced in January 1988 at a nominal rate of one million pounds U_3O_8 per year, and is expected to continue at that rate through 1995. The two companies each plan to market their own shares of production to US and foreign consumers.

Corporate Background

Chevron Corporation is an integrated petroleum company with operations in the USA and more than 95 other countries. At the end of 1987, the company had total assets of $34.5 billion and approximately 51,700 employees worldwide. Based on revenues, Chevron ranks as the fourth largest US petroleum company and one of the ten largest US industrial companies.

Chevron Resources Company, a corporate unit of Chevron Corporation, explores for and develops minerals and non-petroleum energy sources throughout the world. Headquartered in San Ramon, California, Chevron Resources Company operates the following projects:

- Mt. Taylor uranium mine in New Mexico
- Rhode Ranch uranium mine and Panna Maria uranium mill in Texas
- Vernal phosphate mine in Utah
- American Gilsonite Company gilsonite mine in Utah
- Mt. Wilkinson gold mine in western Australia
- Herber geothermal reservoir in California's Imperial Valley, which provides geothermal heat for operating a geothermal power plant
- Roosevelt Hot Springs geothermal reservoir in Utah serving a geothermal power plant
- Geothermal resource fields in Nevada supporting power plants at Beowawe and Desert Peak
- Stillwater Mining Company platinum and palladium mine and mill in Montana

Active mine exploration and/or evaluation programs are underway in the USA, Chile, Ireland, Canada, Australia, and the Dominican Republic. Chevron Resources has more than 1,100 employees worldwide.

Total American Mining, Inc., headquartered in Houston, Texas, is a wholly-owned subsidiary of Total Energy Resources, Inc., which in turn acts as the holding company for Total Compagnie Française des Pétroles (TOTAL), the international energy and mining concern. The parent TOTAL has been involved in uranium exploration and mining since 1970, and operates two mines in France (Mailhac-sur-Benaize and Saint Pierre du Cantal) that together produce approximately 1.4 million pounds U_3O_8 per year. In addition, TOTAL participates in or maintains ownership interests in other uranium projects worldwide.

During 1987, Total American Mining acquired interests in two uranium mining operations in the South Texas district of the USA. In early 1987, Total American Mining purchased the West Cole in-situ leach mine from Tenneco, who had operated it from 1981 to 1984. The project was restarted in mid-1988, and current production capacity is in excess of 200,000 pounds U_3O_8 per year. NUEXCO expects it to continue at that rate at least through the mid-1990s. Total American Mining also acquired a 45-percent interest in the Rhode Ranch conventional mine, which began production in 1988. A wholly-owned subsidiary, Total Minerals Corporation (Total), formerly known as Minatome, manages the company's interests in both projects, and handles the marketing efforts. Total is the project operator at West Cole, while Chevron is the operator at Rhode Ranch.

On August 9, 1988, Total announced that it had acquired the Alta Mesa in-situ property in Brooks County, South Texas, roughly 90 miles from West Cole. The company estimates recoverable reserves at five to twenty million pounds U_3O_8. Previously, some 400 test holes had been

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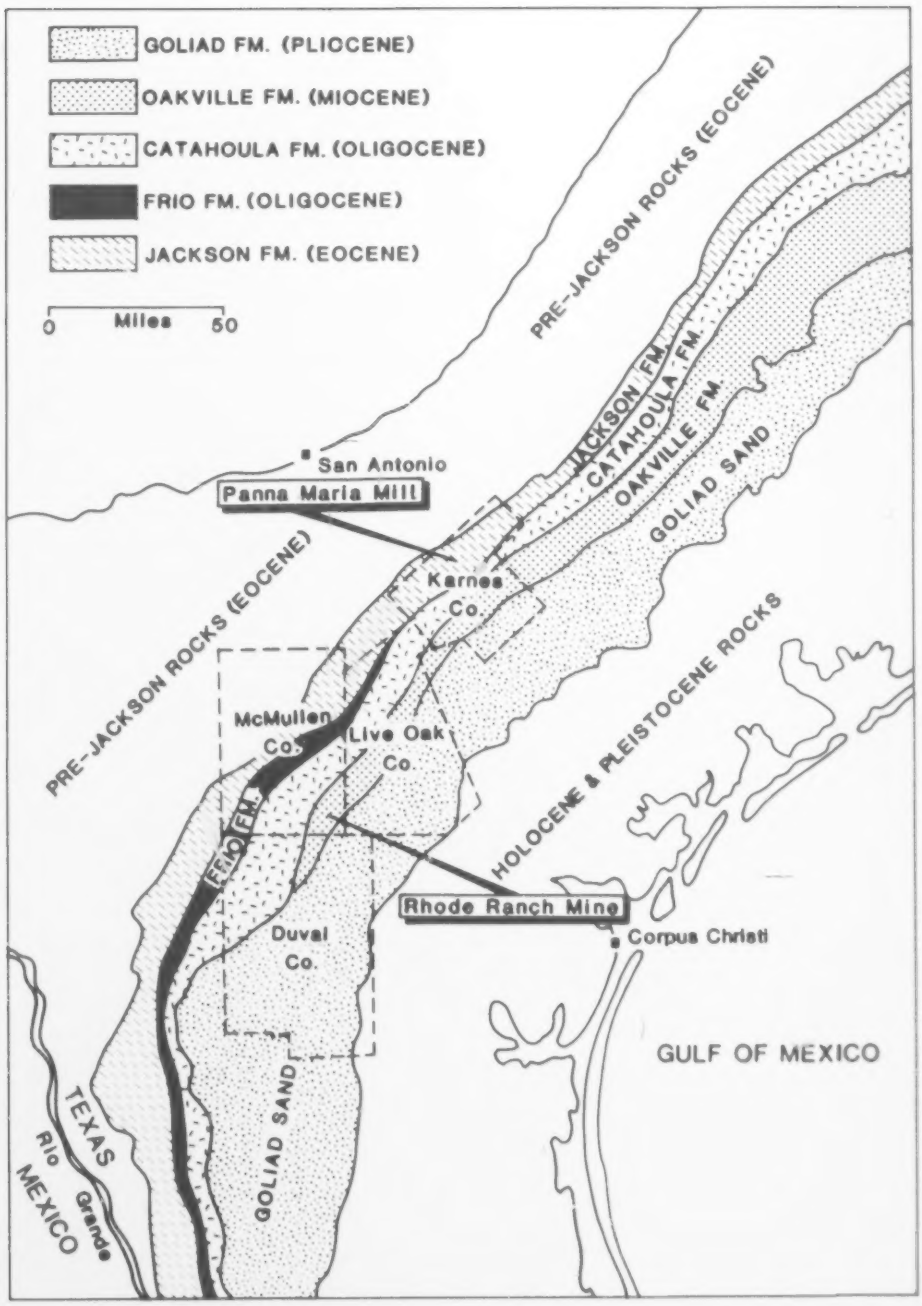

Figure 1. Geologic map of the South Texas Uranium District.

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drilled on the property, and Total will be studying that data and developing a production plan over the next six months. Initial production is scheduled for 1992.

Regional Geology

Uranium deposits of the South Texas district occur in Tertiary sediments which outcrop in a trend closely paralleling the shoreline of the Gulf of Mexico. The trend of mineralization extends to the southwest about 400 miles from Fayette County to Starr County on the USA/Mexico border. (The mineral trend is known to continue another 100 miles into Mexico). Figure 1 shows the outcrop pattern of the Tertiary formations throughout the mineral trend. The principal areas of interest are within McMullen, Karnes, Live Oak, and Duval counties. Important uranium mineralization has been found in eight stratigraphic units of late Eocene to Pliocene age.

Evidence of structural activity throughout the district is limited to a one-degree dip of the beds toward the Gulf Coast and to minor faulting which tends to parallel the strike of the Tertiary formations.

The Tertiary formations of South Texas were deposited in a coastal marine and continental environment. The uranium-bearing formations consist of thick tuffaceous and clay units (the Fant Tuff and Frio Clay); sandstone units (Oakville, Tordilla, Deweeville and Dillworth); and fine to coarse-grained sandstone and conglomeratic units (Goliad and Soledad). The entire sequence is characterized by oscillating depositional patterns marked by facies changes which commonly include any combination of formational deposit. Carbonaceous material and lignite may occur in light to heavy concentrations throughout the more sandy units. The predominant depositional patterns of the Eocene formations are related to beach and barrier-bar structures; the younger formations are associated with continental deposition consisting of fine to coarse sand and conglomeratic units. The source of the fine to coarse sand and conglomeratic material may have been in West Texas and northern Mexico; the tuffs were deposited during regional volcanic activity.

Uranium mineralization is commonly found in sand and sand/clay facies filling erosional channels, and in well-defined beach and barrier structures. The most important ore deposits are associated with depositional changes in fluvial channel environments. A greater concentration of uranium often occurs where lignite and carbonaceous material are abundantly dispersed throughout sand units, especially where permeability is relatively high. There is also an apparent relationship between the concentrations of uranium and clay minerals present in certain sand/clay host units. The clay particles acted to restrict the normal flow of mineral-bearing solutions and, consequently, afforded the rapid precipitation of uranium, enriching the clay-bearing unit. The uranium deposits of the district are believed to have been formed by epigenetic process-placement of the uranium which occurred after and totally independent of the deposition of the host formation.

The principal source of uranium mineralization is considered to be the thick volcanic ash (tuff) sequence of Miocene Age that covered the entire region. As the tuff formation eroded, primarily toward the gulf, the contained uranium was leached from the tuff to be absorbed and transported downdip by oxygenated ground water. Precipitation of the uranium in a favorable host rock occurred in a reducing environment. This environment was probably created by the upward migration of hydrogen sulfide and/or methane gas associated with deeper deposits of oil and gas. Formation permeability and faulting are the main factors controlling the migration of the reductants to the surface.

Site Geology

Uranium mineralization at Rhode Ranch occurs within fluvial sediments of the Oakville Formation at depths of 75 to 180 feet. In the mine area, the Oakville has been subdivided into three members, each of which has two zones. These members are from upper to lower, the Magnolia, the Manuel, and the Rincon.

Uranium occurs primarily in the Manuel and Rincon. The Magnolia member is approximately 100 feet in thickness and is composed of an upper clay zone and a lower sandy zone. The upper zone has been partially eroded over much of the mine area. The Manuel member includes a silty and sandy clay zone (10-35 feet in thickness) and a lower sandy zone (10-25 feet in thickness) capped by calcite cementation. An upper clay and a lower sand comprise the Rincon which has a total thickness of about 30 feet, but which pinches out in the western portion of the mine area.

Mineralization at Rhode Ranch occurs in roll fronts primarily as coffinite and is often encapsulated in pyrite and/or marcasite. A northeast-trending fault about one-half mile to the southeast of the deposit is thought to be the source of sulfur (from hydrogen sulfide) for these minerals.

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Several stages of sulfidization and reduction are in evidence in the roll fronts. It is postulated that re-reduction may be responsible for the higher-than-average (for the South Texas district) ore grades encountered at Rhode Ranch.

Reserves

Current reserves at Rhode Ranch have been estimated by Chevron and Total to include almost 7 million pounds of mill-recoverable U_3O_8. This estimate was compiled from a detailed analysis of some 1,400 drillholes in the immediate mine area utilizing the polygonal method of reserve estimation, and with full consideration of the economic character of each drillhole. Cutoff criteria included a minimum thickness of 2.0 feet at a grade of 0.08 percent U_3O_8. Dilution in the amount of 35 percent has been added to arrive at an estimated mill head grade of 0.26 percent U_3O_8.

Chevron and Total are currently converting the reserve analysis to a PC-based Kriging system which will allow additional flexibility and speed. In addition to the 1,400 drillholes in the immediate mine area, another 5,000 holes were drilled on other areas of the property. All of the drillholes were logged for gamma radiation, self potential, and resistivity. Interpretation of the gamma activity provides definition of the ore grade and thickness of mineralization, while the self potential and resistivity assist in analysis of the lithology. Neutron density logs were included on many drillholes and have proved valuable in defining the thickness, hardness, and extent of the caprock.

Licensing and Environment

In Texas, uranium mills are regulated by the Texas Department of Health (TDH), and uranium mines by the Railroad Commission of Texas (RRC). Both agencies have responsibilities for regulating tailings ponds and other waste water ponds associated with milling.

Chevron obtained the initial radioactive materials license for the Panna Maria mill on September 23, 1977. An application to renew that license was submitted in 1980 and Chevron was authorized to continue operating under the terms of the original license pending processing of the renewal application. Following the elimination of a substantial backlog of permitting activities, the TDH published an environmental assessment of the mill license renewal in September 1987. The public hearing process required for renewal was recently initiated, but may extend for some time since local opposition to the nuclear fuel cycle has been voiced only recently for the first time. This opposition, however, is not expected to be substantive.

The primary concern addressed by the mill licensing permit is the release of radioactive material into the atmosphere and/or groundwater. The Panna Maria mill incorporates extensive controls on each potential release and operates as a no-discharge facility. Drainage controls and impoundments for the confinement of liquid waste include the following: Three drainage-collection ponds on the periphery of the tailings area, three mine and mill drainage ponds, an industrial waste pond, a molybdenum sludge waste pond, the main tailings disposal area, and an emergency tailings pond.

Potential atmospheric releases are subject to an aggressive dust control program at the ore stockpile as well as separate high-efficiency dust collection/scrubbing systems on the yellowcake dryer and the lump breaking/packing unit. Leach tank fumes are collected and scrubbed before discharge and the ammonia precipitation circuit is covered and provided with a vapor collection, scrubbing, and venting system.

The operating permit for the Rhode Ranch mine was issued on June 8, 1987 by RRC as a transfer of the original permit obtained by Anaconda. The transfer process included a commission review and a public notice/public comment period, but was nevertheless completed in less than twelve months. A reclamation bond of $3.3 million was set for the total permit area of 8,900 acres.

Mining

Ultimately, the Rhode Ranch orebody will be mined over a distance of almost two miles (see Figure 2). The pit will be narrow, about 200 feet in width on average — a condition which requires the utmost in planning and coordination in order to ensure a continuous cycle of stripping and mining.

The mining sequence includes topsoil removal, overburden stripping, waste mining, ore mining, backfilling, and reclamation.

Topsoil is removed sequentially by scrapers from all areas to be disturbed during the mining process and is either stockpiled for use in reclamation or used to construct a continuous drainage berm around the periphery of the pit. It is notable that all areas subject to disturbance during the mine life (except for the shop/office area) are

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Figure 2. The Rhode Ranch Mine.

located within the ultimate pit boundaries in order to minimize reclamation requirements.

The overburden removal fleet includes 44-cubic yard scrapers and tracked dozers. Most of the overburden can be ripped with the tracked dozers to facilitate loading, but some 5 to 10 percent requires blasting. Blast holes are drilled on a 7 foot x 7 foot pattern and are 3-1/2 inches in diameter. The explosive is ANFO and detonation is by primacord. The total quantity of overburden to be removed during the life of the mine is approximately 21-million bank cubic yards, or 15-bank cubic yards of overburden per ton of ore.

The mine plan incorporates a continuous mining/backfilling system which minimizes the stockpiling of overburden. Even though mining commenced only a few months ago in the early spring, the initial mined out area has been completely backfilled and is now ready for topsoiling and seeding. The maximum overburden stockpile will be about 3.7 million BCY.

Hydraulic backhoes with a bucket capacity of about 2.5 cubic yards are used to selectively mine the ore in thin layers to prevent dilution. Waste and low-grade mineralization occurs in association with the ore at a ratio of about 4.5:1. The total quantity of this waste will amount to 6.3 million tons over the life of the mine. Ore is loaded into 30-ton, off-highway end-dump trucks which haul to the ore stockpile. At the ore stockpile, a front end loader loads 25-ton contract haul trucks for the trip to the Panna Maria mill some 85 miles distant. These trucks complete two round trips per shift and operate two shifts per day.

Work schedules at the mine are designed to provide a blend of high equipment utilization with maximum control of the ore mining process. The stripping operation works two 10-hour shifts per day, four days per week. Mining, however, occurs during daylight shifts only, seven days per week, with two crews working alternate weeks of 80 hours per seven-day period.

One of the key factors in the decision to proceed with the Rhode Ranch project in spite of low uranium prices was the availability of almost all the mining fleet from the Panna Maria mine which ceased operation in 1985. The availability of this equipment, along with that of the Panna Maria mill, minimized the capital investment required to initiate the project.

Grade Control

As in most roll-front uranium deposits, mineralization at Rhode Ranch can exhibit both gradational and sharp

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boundaries which must be carefully defined during the mining process in order to limit dilution to acceptable levels. The grade control process begins with the compilation of "slice" maps at one-foot intervals for the entire orebody. These maps are issued to grade control technicians, as required, for each specific area of the mine as it is developed. The maps provide an estimated outline of the ore derived from drillhole data. As each two-foot mine bench is exposed, the technicians adjust this estimated outline to actual by probing the surface of the bench with T-probe scintillometers. Additional definition is obtained by drilling small diameter holes to a depth of two feet with hand-held augers at intervals of 10 to 20 feet. The cuttings from these drillholes are assayed by the beta/gamma method at a laboratory trailer located in the pit. Strict adherence to grade control guidelines has limited dilution to approximately 20 percent. The original mine plan had made allowance for dilution of 35 percent.

Personnel

With a work force of 125 employees, the Rhode Ranch/Panna Maria project's productivity is 8,000 pounds U_3O_8 per man year, one of the highest levels in the US uranium industry. These employees are distributed as follows:

Mine	60
Mill	49
General & Administrative	16

Certainly, a major portion of the project's high productivity can be directly related to the high level of experience within the work force. Most of the mine and mill employees have been at Panna Maria since startup in 1979, and had worked in the industry for other producers prior to that time. The work force is non-union and turnover is negligible.

Milling

Flexibility has been the watchword at Panna Maria, as the mill has now performed five entirely different uranium recovery operations.

The Panna Maria uranium mill commenced operations on February 23, 1979 as an integral part of Chevron's first mining project. That project was based on the exploitation of three low-grade (0.05% U_3O_8) orebodies adjacent to the mill. A $50 million investment was required to develop the project which produced a total of 5.2 million pounds U_3O_8 from 5.2 million tons of ore. This production was obtained from the East, West, and Swientek open pits at an average rate of 2,500 tons per day. Mining at the final West pit was completed in May 1985, and all three pits have been fully reclaimed (see Figure 3). Overall uranium recovery for the project was 93.5 percent.

During the period July-November 1985, following the completion of mining, much of the acid within the tailings pond was neutralized with caliche obtained from nearby sources. The treated water was used for dust suppression during reclamation, and uranium present in the fluids was recovered at a rate of about 225 pounds per day.

Tailings neutralization was suspended in November 1985 in order to prepare the mill for the processing of high-grade (0.50% U_3O_8) ore from Chevron's Mt. Taylor underground mine in New Mexico. These preparations, including the construction of a rail siding to receive the ore, were completed in early 1986. As an interim activity prior to startup on Mt. Taylor ore, the Panna Maria mill processed some 4,000 tons of by-product calcium flouride from a conversion plant. This material contained in excess of two percent U_3O_8. The Panna Maria mill was also used previously to dry uranium-bearing slurry produced at Chevron's Palangana Dome in-situ leaching

Figure 3. Reclaimed area of the Panna Maria Mine.

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project. Ore from Mt. Taylor was milled at Panna Maria during the period April 1986 to Febrruary 1988, with total uranium recovery exceeding three million pounds during this period.

The recovery process at Panna Maria includes the following basic steps: ore receiving, grinding, leaching, solid-liquid separation, clarification, solvent extraction and product precipitation, dewatering, and drying.

Ore Receiving

Ore from the Rhode Ranch mine is hauled by truck to Chevron's Panna Maria mill at Panna Maria, Texas for processing. The haulage route covers 84 miles of rolling ranch and farmland, through which the subcontractor's 25-ton, over-the-road, covered trucks make two round trips per shift.

The ore is dumped on a prepared stockpile pad in a series of windrows and separated, as required by grade, carbonate content, or other factors which might influence the recovery process. Notably, dust on the stockpile pad is controlled by spraying water over the entire area with irrigation-type nozzles located around the perimeter of the pad. The paid itself is sloped to direct all drainage toward a central storage pond.

A front-end loader retrieves ore from the windrows and dumps it onto a 24-inch grizzly covering the coarse ore bin. Oversize pieces are reduced with a tractor-mounted pneumatic pick. Coarse ore is reclaimed with an apron feeder and travels by belt conveyor to the semi-autogenous grinding (SAG) mill.

Grinding and Leaching

The SAG mill is 16.5 feet in diameter. It utilizes a 5- to 6-percent ball load and is powered by a 500 HP motor. The ore is wet ground with hot (160 degrees F) water from a geothermal well tapping the Carrizo aquifer. This heat accelerates the subsequent chemical reactions at considerable savings in fuel cost. Finely-ground ore is pumped from the SAG mill to a series of wooden leaching tanks 24 feet in diameter and 24 feet high. It is in this leaching process that the flexibility of the Panna Maria mill has been further tested (see Figure 4).

Ore from Rhode Ranch has an average equivalent carbonate content of fifteen percent, whereas ore from the original Panna Maria deposits contained only about five percent carbonate. The increase in carbonate content potentially could result in high acid consumption as well as foaming problems. Both of these concerns were solved by changing from a single-stage leach to a two-stage leach which utilizes a "spent" acid from Chevron's El Paso refinery. The first stage leach performs as an "acid kill" circuit, neutralizing excess acid from the second-stage leach. In the first-stage leach, virgin sulphuric acid and high-acid recycled solution from the second-stage leach are contacted with freshly ground ore. The second-stage leach utilizes the "spent" (approximately 90 percent

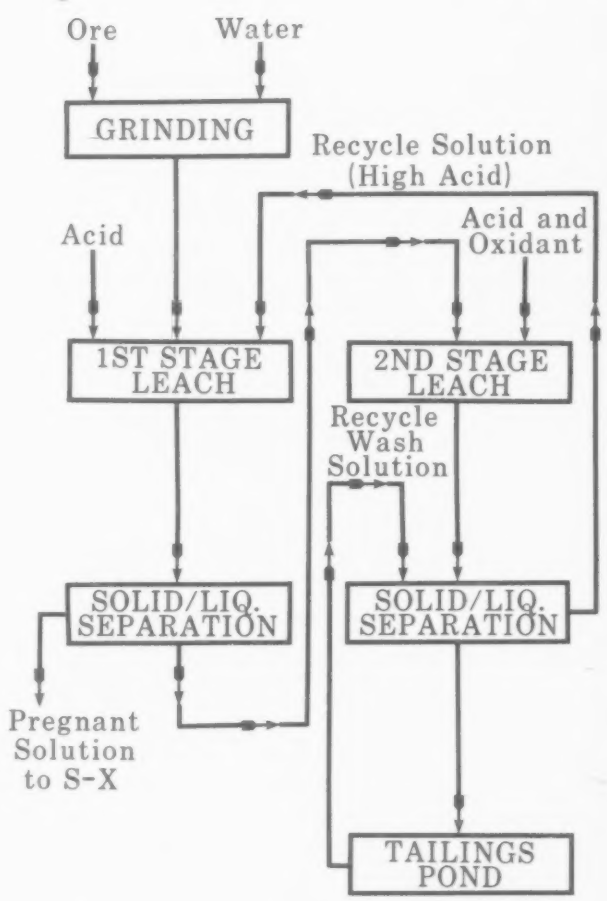

Figure 4. Leaching circuit flowsheet.

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strength) refinery acid. Concentration of acid is maintained at a high level to maximize uranium recovery. Both stages act to bring the uranium into solution after oxidation with sodium chlorate. Acid consumption in the two-stage process is still relatively high at about 300 pounds per ton of ore, but is some 25 percent less than in a single-stage leach. Panna Maria ore required 100 pounds of acid per ton of ore. Total leaching time currently is 16 hours — 0.5 hours in the first stage and 15.5 hours in the second stage.

Separation and Clarification

Uranium-carrying (pregnant) solution is separated from the barren, residual rock particles (tailings) in a five-stage series of counter-current decantation steps. Each step utilizes a large thickener tank 110 feet in diameter and 15 feet in height. In these tanks, solution flows in one direction and progressively is enriched, while the tailings flow in the other direction and are progressively depleted. A flocculent is added to aid particle settling. Tailings are discharged to a confinement area (tailings pond).

Pregnant solution is passed through a series of anthracite sand filters to remove undissolved solids.

Solvent Extraction

Following clarification, the pregnant solution is pumped to the solvent extraction circuit where the dissolved uranium in acid/aqueous solution is transferred to an organic solvent containing 90 percent kerosene, 4.0 percent isodecanol, and 6.0 percent amine. Amine is the active ingredient in the process. Uranium in the pregnant organic solution is then stripped into a solution of ammonium chloride for final recovery.

The barren organic solution tends to accumulate impurities such as molybdenum which must be scrubbed continuously by a basic solution.

Product Finishing

Uranium exists within the pregnant strip solution as either a chloride or sulphate, both of which are amenable to precipitation as "yellowcake" through the addition of anhydrous ammonia. The ammonia is added to agitated precipitation tanks (Figure 5). Following precipitation, the slurry is dewatered and washed to remove soluble impurities and to reduce the water content. After dewatering in a continuous centrifuge, the uranium

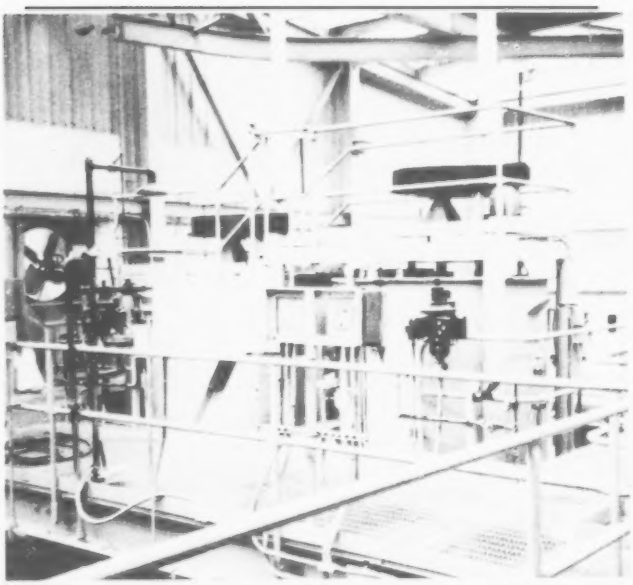

Figure 5. Yellowcake precipitation units at the Panna Maria Mill.

precipitate is fed to a four-stage hearth dryer where it is heated to 1,400 degrees C in order to decompose and expel ammonia, sulfates, and chlorides. The resulting U_3O_8 product is passed through a lump breaker to yield a powdered product within a suitable size range. It is then packaged in 55-gallon drums for shipment.

Operating Parameters

The Panna Maria mill was designed and constructed by Kaiser Engineers to process 3,000 tons per day of uranium-bearing sandstone ore. Installed horsepower totals 3,000, but the average operating load is about 2,500. Typical reagent consumption rates for Rhode Ranch ore are as follows:

Ammonia	6 lbs/ton of ore
Kerosene	0.25 gal/ton of ore
Sodium chlorate	6 lbs/ton of ore
Sulphuric acid	300 lbs/ton of ore
Hydrochloric acid	5 lb/ton of ore

Uranium recovery on Rhode Ranch ore is currently averaging 97 percent. The operating schedule is based on two twelve-hour shifts per day, approximately seven days on and seven days off. ■

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HISTORICAL MARKET DATA

HISTORICAL EXCHANGE VALUES
Determined as of the last day of the month indicated ($US/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	16.75	16.65	16.65	16.75	16.65	16.55
1988	16.30	16.15	15.90	15.75	15.40	15.10	14.75	**14.15**				

HISTORICAL US PREMIUM (Relative to the Exchange Value)
Determined as of the last day of the month indicated ($US/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	0.65	0.75
1987	0.85	1.00	1.50	1.50	0.90	0.60	2.50	2.35	2.10	1.65	0.85	0.65
1988	0.70	0.50	0.15	0.25	0.60	0.00	0.00	**0.60**				

HISTORICAL TRANSACTION VALUES
Determined as of the last day of the month indicated ($US/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.30	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.05	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	17.30	17.55	18.20	18.05	17.80	17.20
1988	16.85	16.65	16.55	16.45	16.10	15.80	15.45	**15.00**				

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated ($US/lb. U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.80	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.90	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.90	1.90	1.90
1988	1.90	1.80	1.80	1.80	1.80	1.80	1.85	**1.95**				

HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated ($US/kg. U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	47.50	47.00	46.75	47.00	47.00	47.00
1988	46.50	46.00	45.50	45.25	44.75	44.00	42.75	**41.00**				

HISTORICAL US UF_6 PREMIUM (Relative to the UF_6 Value)

Determined as of the last day of the month indicated ($US/kg U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	2.50	2.50
1987	2.50	2.50	3.50	3.00	2.25	1.75	6.50	6.00	4.25	3.10	2.25	2.00
1988	1.25	1.25	0.50	0.50	1.00	0.00	0.00	**0.00**				

HISTORICAL SWU VALUES (at 0.30 Percent Tails Assay)

Determined as of the last day of the month indicated ($US per SWU)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	80	80	80	80	75	78	78	78	78	78	80	80
1987	80	80	77	77	75	73	75	75	73	69	73	73
1988	73	73	70	68	68	68	68	**65**				

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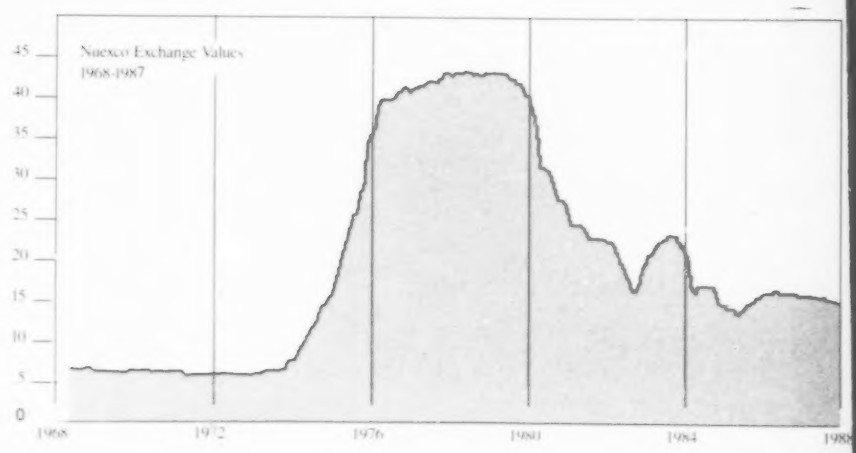
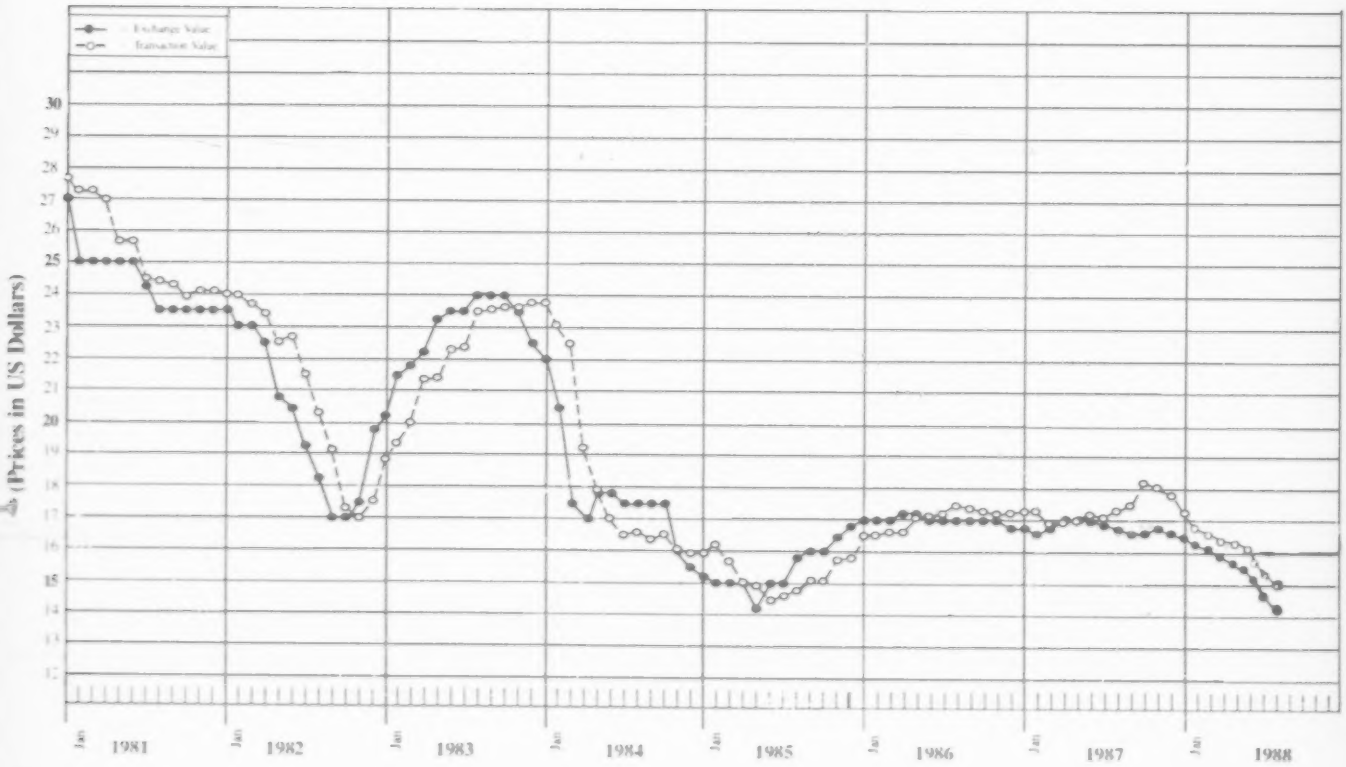
HISTORICAL MARKET DATA





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US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26.16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3
1986	13.5	18.9	$30.01	13.5	$20.07	1.6
1987	13.1P		$27.45P	14.0P	$19.31P	

P = Preliminary

[1]Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Resources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, Assistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985). 1986: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1986). 1987: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey"(1987).

[2]Sources: 1976-1982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3]Excludes direct imports by domestic utilities.

[4]Includes imports by domestic utilities and domestic suppliers.

[5]Includes delivery commitments to domestic utilities and agents.

[6]Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

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HISTORICAL MARKET DATA

VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00
1986	12,000	9.5	ECU 31.50	$31.00	ECU 18.00	$17.75
1987	14,000	17.0	ECU 28.25	$32.50	ECU 15.00	$17.25

[1]The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EEC.
[2]The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.
[3]For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.
[4]Exchange rates are published by European Communities Statistical Office and the International Monetary Fund.

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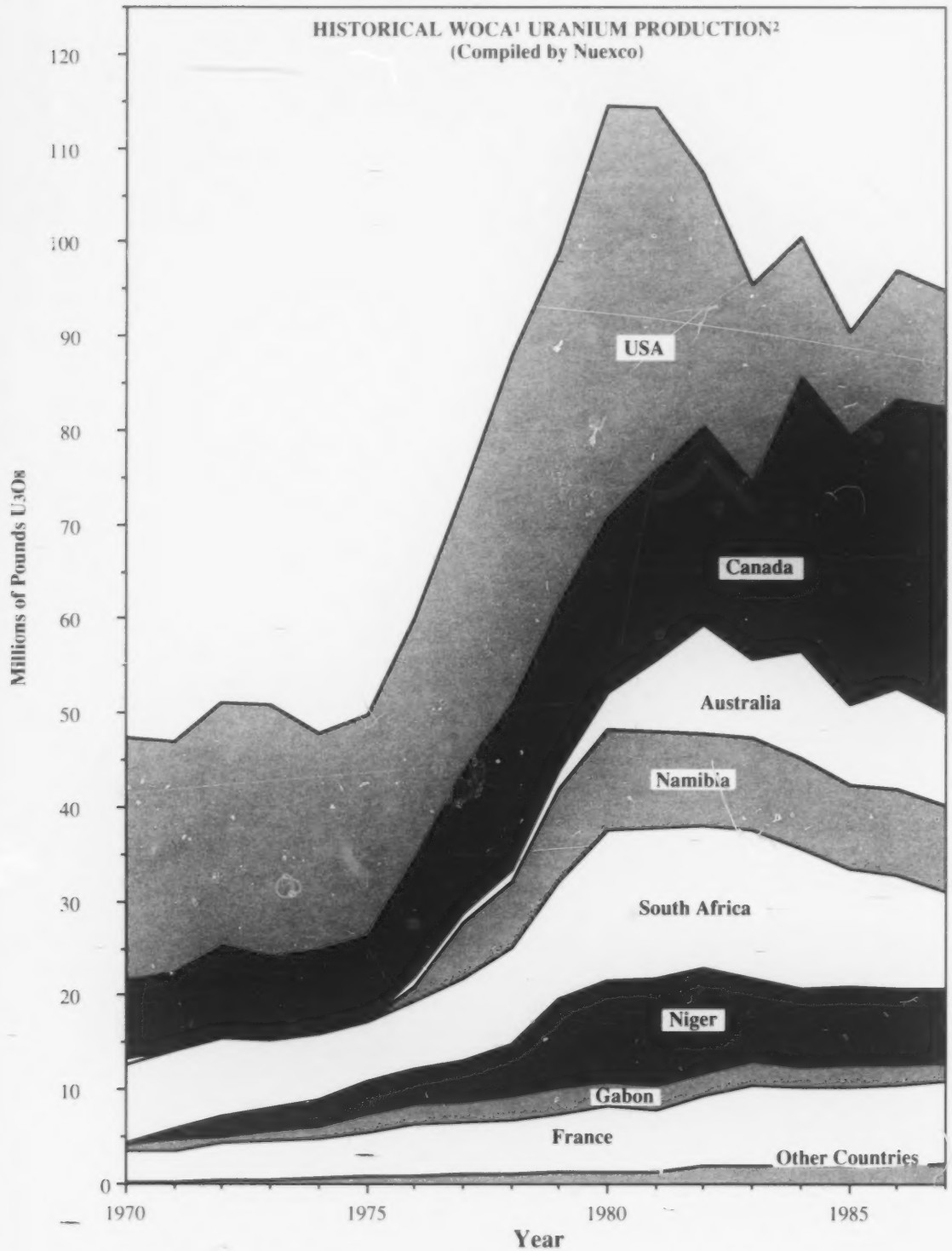

[1] WOCA = World Outside of Centrally-Planned Economic Areas.
[2] 1987 production data are preliminary.

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GOVERNMENT STATISTICS

AUSTRALIA

		Consumer Price Index[1] (1980/1981 = 100)	Price Index of Materials Used in Manufacturing Industry — All Groups[2] (1984/1985 = 100)	Award Rates of Pay Indexes Australia - Adult Males In Mining Wage Earners, Weekly Rates[3] (June 1976=100)
1975	Avg.[4]	57.9	36.3	82.1
1976	Avg.	65.7	40.7	99.7
1977	Avg.	73.8	46.3	110.8
1978	Avg.	79.7	52.0	117.7
1979	Avg.	86.9	69.5	127.9
1980	Avg.	95.8	83.1	140.8
1981	Avg.	105.0	85.9	154.1
1982	Avg.	116.7	89.0	174.9
1983	Avg.	128.5	96.9	181.9
1984	Avg.	133.6	98.0	194.4
1985	Avg.	142.6	107.3	198.7 (Jan - May) 101.1 (Jun - Dec)[5]
1986	Avg.	155.5	101.5	104.9
1987	Avg.	168.7	108.9	—
Jan	1987	—	106.2	108.8
Feb	1987	—	108.9	108.8
Mar	1987	164.7	108.4	111.7
Apr	1987	—	108.3	111.7
May	1987	—	108.1	111.7
June	1987	167.2	108.1	111.8
July	1987	—	108.7	111.9
Aug	1987	—	110.5	111.9
Sep	1987	170.0	109.3	112.1
Oct	1987	—	108.6	112.2
Nov	1987	—	110.0	112.2
Dec	1987	172.9	111.9	112.3
Jan	1988	—	112.4	—
Feb	1988	—	112.3	—
Mar	1988	176.0	112.3	—
Apr	1988	—	112.4	—
May	1988	—	114.1	—

P = Preliminary **R** = Revised since last month

[1]Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: Financial year July 1980 to June 1981 =100.0). Figures shown at end of quarter represent quarterly average.
[2]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0).
[3]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.
[4]Monthly data for the period 1967 to 1986 appear in Report 233.
[5]Base: June 1985 = 100 and includes salary earners as well as wage earners.

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CANADA

		Industrial Products Price Index: All Commodities[1] (1981 = 100)	Consumer Price Index: All Items (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2] Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Metal Rolling, Casting and Extruding (SIC 298)	Chemicals and Chemical Products Industries (SIC 372-379)
1979	Avg.	80.0	80.7	—	—	—	—	—
1980	Avg.	90.7	88.9	—	—	—	—	—
1981	Avg.	100.0	100.0	—	—	—	—	—
1982	Avg.	106.7	110.8	—	—	—	—	—
1983	Avg.	110.4	117.2	17.22	—	14.18	10.67	11.10
1984	Avg.	115.4	122.3	17.89	—	14.97	11.11	11.68
1985	Avg.	118.6	127.2	18.53	16.48	15.56	11.85	12.12
1986	Avg.	119.6	132.4	19.38	16.70	15.76	12.28	12.58
Jan	1987	120.0	135.2	19.53	16.93	16.03	12.58	12.89
Feb	1987	119.8	135.8	20.33	17.20	16.21	12.66	13.11
Mar	1986	120.4	136.4	20.04	17.14	16.15	12.58	13.02
Apr	1987	121.2	137.0	20.47	17.38	16.26	11.99	13.27
May	1987	122.0	137.8	20.50	17.12	15.96	11.44	13.19
June	1987	122.5	138.2	20.23	16.94	15.70	12.77	12.88
July	1987	123.2	139.2	19.75	16.73	15.63	12.52	12.98
Aug	1987	123.8	139.3	19.64	16.98	15.87	12.65	13.03
Sep	1987	124.1	139.3	19.85	17.20	16.25	12.57	13.40
Oct	1987	124.5	139.8	20.06	17.31	16.33	13.01	13.37
Nov	1987	125.1	140.4	20.47	17.50	16.50	12.63	13.53
Dec	1987	125.5	140.5	20.62	17.31	16.37	12.54	13.75
Jan	1988	126.4	140.8	20.70	17.54	16.65	12.82	13.73
Feb	1988	125.9	141.3	20.94	17.97	17.07	13.01	13.59
Mar	1988	126.2	142.0	20.55	17.88	16.78	13.10	13.62
Apr	1988	126.8	142.5	20.03	18.50	15.92	13.32	13.66
May	1988	127.2	143.4	20.92R	17.69R	17.03R	13.02R	13.58
Jun	1988	127.1	143.6	21.04P	17.69P	16.85P	13.02P	13.72P
Jul	1988	—	144.5	—	—	—	—	—

P = Preliminary **R** = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011).—Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Monthly data for the period 1967 to 1986 is found in Report 233.
[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours." Monthly data for the period 1983 to 1986 is found in Report 233.
[3]Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

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GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1985 = 100)	Production Price Index All Groups[4] (1980 = 100)	Total Employment in Mining and Quarrying[5]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand)[5]
1975	Avg.	16.71	—	29.4	52.1	639,473	1,003,217
1976	Avg.	19.30	—	32.7	59.9	671,240	1,212,983
1977	Avg.	23.87	—	36.3	67.7	712,006	1,420,670
1978	Avg	27.14	—	40.3	74.3	658,261	1,502,975
1979	Avg.	30.18	—	45.6	85.6	686,599	1,795,638
1980	Avg.	35.53	—	51.9	100.0	709,042	2,237,689
1981	Avg.	41.89	—	59.8	113.6	722,918	2,756,928
1982	Avg.	47.25	104.2	68.6	129.4	702,041	3,181,584
1983	Avg.	51.88	115.0	77.1	143.1	700,901	3,563,282
1984	Avg.	58.95	130.3	86.0	155.1	711,511	4,134,390
1985	Avg.	68.76	151.6	100.0	181.2	724,587	4,778,612
1986	Avg.	80.22	177.9	118.6	216.6	756,637	5,767,950
1987	Avg.	—	—	137.7	246.8	750,256	—
Jan	1987	—	—	128.9	233.9	750,496	529,682
Feb	1987	—	—	130.3	237.0	758,230	600,258
Mar	1987	88.17	197.1	132.4	239.6	763,003	536,033
Apr	1987	—	—	134.1	242.5	765,309	535,876
May	1987	—	—	135.6	243.6	761,026	531,732
Jun	1987	90.74	203.5	136.6	244.9	763,319	571,407
July	1987	—	—	138.2	246.8	764,810	624,954
Aug	1987	—	—	140.2	249.9	761,338	564,387
Sep	1987	100.79	224.7	142.0	252.4	742,417	587,707
Oct	1987	—	—	143.6	255.5	725,599	599,116
Nov	1987	—	—	144.8	256.3	734,630	616,725
Dec	1987	100.34	267.0	145.9	258.3	712,896	613,262
Jan	1988	—	—	147.2	261.5	711,983	615,889
Feb	1988	—	—	148.2	265.7	730,313	621,757R
Mar	1988	102.90R	234.0	150.2	268.4	—	619,117
Apr	1988	—	—	151.9	272.7	—	621,757
May	1988	—	—	153.1	276.1	—	—
Jun	1988	103.59	234.0	153.6	278.2	—	—
Jul	1988	—	—	155.3	—	—	—

P = Preliminary **R** = Revised since last month

[1]Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly. Historical Data by month appears in Report 236.

[2]Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3]Central Statistical Service, Pretoria: All income groups-weighted average, Historical Data by month appears in Report 236.

[4]Central Statistical Service, Pretoria: All commodities for consumption in South Africa.

[5]Central Statistical Service, Pretoria: Historical Data by month appears in Report 236.

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UNITED STATES

		Producer Price Index[1]		Consumer Price	GNP Implicit Price	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4]			
		Industrial Commodities (1982 = 100)	All Commodities (1982 = 100)	Index[2] (1982-1984 = 100)	Deflator[3] (1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980	Avg.	88.0	89.8	82.4	85.7	10.26	10.63	8.30	6.94
1981	Avg.	97.4	98.0	90.9	94.0	11.55	11.98	9.12	7.62
1982	Avg.	100.0	100.0	96.5	100.0	12.31	12.93	9.96	8.21
1983	Avg.	101.1	101.3	99.6	103.9	12.58	13.43	10.58	8.67
1984	Avg.	103.3	103.7	103.9	107.7	13.05	13.43	11.07	9.04
1985	Avg.	103.7	103.2	107.6	111.2	13.38	13.74	11.56	9.46
1986	Avg.	100.0	100.2	109.6	114.1	12.46	13.48	11.98	9.65
1987	Avg.	102.6	102.8	113.6	—	12.52	12.98	12.37	9.88
Jan	1987	100.4	100.5	111.2	—	12.72	12.96	12.17	9.82
Feb	1987	100.8	101.0	111.6	—	12.63	12.80	12.21	9.82
Mar	1987	101.1	101.2	112.1	116.1	12.58	12.76	12.24	9.82
Apr	1987	101.6	101.9	112.7	—	12.51	12.84	12.30	9.81
May	1987	101.9	102.6	113.1	—	12.50	12.87	12.32	9.81
Jun	1987	102.4	103.0	113.5	117.2	12.52	12.88	12.28	9.83
Jul	1987	103.1	103.5	113.8	—	12.41	13.02	12.37	9.86
Aug	1987	103.7	103.8	114.4	—	12.40	13.01	12.33	9.98
Sep	1987	103.5	103.7	115.0	117.8	12.50	13.29	12.56	9.94
Oct	1987	104.0	104.1	115.3	—	12.42	12.99	12.50	9.92
Nov	1987	104.2	104.2	115.4	—	12.54	13.11	12.55	9.98
Dec	1987	104.1	104.1	115.4	118.7	12.60	13.14	12.61	10.03
Jan	1988	104.3	104.5	115.7	—	12.77	13.03	12.55	10.02
Feb	1988	104.6	104.8	116.0	—	12.71	12.96	12.55	10.02
Mar	1988	104.7	104.9	116.5	119.4	12.59	13.17	12.53	10.04
Apr	1988	105.6	105.8	117.1	—	13.08	13.17	12.57	10.09
May	1988	106.1	106.5	117.5	—	12.99R	13.09	12.59R	10.12
Jun	1988	106.5	107.4	118.0	120.6	13.18P	13.12P	12.60R	10.15R
Jul	1988	106.7	107.8	118.5	—	—	—	12.71P	10.20P

P = Preliminary **R** = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents. Historical data is presented in Report 233.

[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items. Historical data is presented in Report 233.

[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted. Historical data is presented in Report 233.

[4]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Historical data is presented in Report 233.

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